N13-27758 CR-133954



LMSC-A991396 30 JUNE 1973

CASE FILE COPY

FINAL REPORT

SHUTTLE CRYOGENICS SUPPLY SYSTEM

OPTIMIZATION STUDY

VOLUME V A-2

USERS MANUAL FOR

SPACE SHUTTLE ORBIT INJECTION SYSTEM ANALYSIS

(SOPSA)

CONTRACT NAS9-11330

Prepared for Manned Spacecraft Center by Manned Space Programs, Space Systems Division

LOCKHEED MISSILES & SPACE COMPANY. INC.

FINAL REPORT SHUTTLE CRYOGENIC SUPPLY SYSTEM OPTIMIZATION STUDY

VOLUME VA-2

USERS MANUAL FOR SPACE SHUTTLE ORBIT INJECTION SYSTEM ANALYSIS (SOPSA)

Contract NAS 9-11330

Prepared for Manned Spacecraft Center By Manned Space Programs, Space Systems Division

FOREWORD

This Final Report provides the results obtained in the Shuttle Cryogenics Supply System Optimization Study, NAS 9-11330, performed by Lockheed Missiles & Space Company (LMSC) under contract to the National Aeronautics and Space Administration, Manned Spacecraft Center, Houston, Texas. The study was under the technical direction of Mr. T. L. Davies, Cryogenics Section of the Power Generation Branch, Propulsion and Power Division. Technical effort producing these results was performed in the period from October 1970 to June 1973.

The Final Report is published in eleven volumes*:

Volume I – Executive Summary

Volumes II, III, and IV - Technical Report

Volume VA-1 and VA-2

Math Model - Users Manual

Volume VB-1, VB-2, VB-3,

and VB-4 Math Model - Programmers Manual

Volume VI - Appendixes

The LMSC Staff participants are as follows:

Study Manager L. L. Morgan

Subsystem Evaluations C. J. Rudey

D. P. Burkholder

C. F. Merlet

W. H. Brewington

Integrated Systems H. L. Jensen

Component Analyses B. R. Bullard

F. L. Bishop

^{*}The Table of Contents for all volumes appears in Volume I only. Section 12 in Volume III contains the List of References for Volumes I through IV.

m	
Thermodynamics	G. E. Heuer
	R. M. Vernon
	J. Gries
	D. R. Elgin
Thermal Protection	G. E. Heuer
•	R. Cima
Fluid Dynamics	D. P. Burkholden
	R. Cima
Propellant Acquisition	M. P. Hollister
	R. K. Grove
Design	R. A. Michael
Structural Analysis	M. L. Vaughn
	C. C. Richie
Instrumentation	R. R. Gaura
Reusability/Reliability	R. F. Hausman
Failure Modes and Effect Analyses	D. C. Saunders
Requirements and Criteria	C. F. Merlet
Safety and Mission Completion	C. F. Merlet
Math Model	R. F. Hausman
	J. McKay

Cryogenic Cooling Subtask

Subsystem Evaluation	H. L. Jensen
Component Analyses	G. Heuer
•	AiResearch
Thermodynamics	R. Cima
Thermal Protection	G E Heuer

CONTENTS

Section		Page
	FOREWORD	iii
	ILLUSTRATIONS	vii
	TABLES	ix
	INTRODUCTION	1
l	SOPSA PROPELLANT FEED SYSTEM ANALYSIS PROGRAM	5
	1.1 Program Description	. 5
	1.2 Input Data	16
	1.3 Input Deck Setup	18
	1.4 Control Cards	18
	1.5 Output Data	20
	1.6 Error Messages	20
	1.7 Restrictions	20
2	SOPSA DATA SAMPLES	21
	2.1 Input Data Listing	21
	2.2 Output Data Listing	21
Appendix		
Α	INPUT DATA FORMATS	

ILLUSTRATIONS

Figure		Page
1	SOPSA Main Program Flow Diagram	2
2	Propellant Feed System Schematic	7
3	Inputs for Curved Line Section	12
4	Inputs for Compound "U" Elbow	12
5	Inputs for 90° Offset Bend	13
6	Inputs for "Z" Bend	. 13
7	Inputs for Gradual Expansion	14
8	Inputs for Contraction	14
9	Propellant Tank Configuration Definition	15
10	Input Data Deck Organization	17
11	Input Deck Setup	19
12	Oxygen Feed System-Orbiter O4OA	24
13	Hydrogen Feed System-Orbiter 040A	25



TABLES

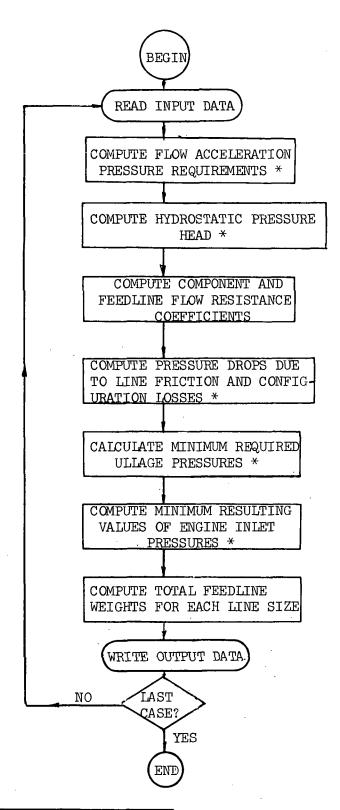
Table		Page
1-1	Feedline Component Specifications	9
1-2	Component Material Flags	11
1-3	Insulation Material Flags	11
2-1	Hydrogen Feed System Configuration	26
2-2	Oxygen Feed System Configuration	27
2 - 3	SOPSA Input Data Listing	29
2-4	SOPSA Output Data Listing	32

INTRODUCTION

SOPSA (Shuttle Orbit Injection Propulsion System Analysis) is a computer program developed by Lockheed Missiles & Space Company to aid in the preliminary design of propellant feed systems for the Space Shuttle Orbiter main engines. The primary purpose of the program is to evaluate propellant tank ullage pressure requirements imposed by the need to accelerate propellants rapidly during the engine start sequence. These requirements can influence the system design for a given engine as well as the suitability of a given system for use with different engines. During the vehicle design phase, the SOPSA program is used to establish feed system weight variations as a function of nominal line diameter and component and line configurations. The weight data are used in conjunction with pertinent cost data to establish optimum feed system designs.

The SOPSA program will generate parametric feed system pressure histories and weight data for a range of nominal feedline sizes. This is accomplished by evaluating tank ullage pressure requirements during the startup phase using the constraints of engine inlet pressure (or NPSP) requirements and instantaneous values of feedline flow resistance. Program flexibility has been incorporated to allow for engine start on the ground or at altitude, computations for oxidizer, fuel, or both oxidizer and fuel feedlines, and a multiple restart capability requiring restart data input only for quantities whose values have changed from the previous case.

As illustrated in the main program flow diagram, Figure 1, the SOPSA program utilizes a simple, in-line computational sequence to solve for the propellant tank ullage pressure requirements. Input data describe the number of main propellant feedline sizes to be considered, and the number of engine feedlines attached to each main feedline (i.e., the number of branch lines feeding each



^{*} NOTE: THESE CALCULATIONS ARE PERFORMED AS A FUNCTION OF TIME FOR EACH CANDIDATE LINE SIZE.

Fig. 1 SOPSA Main Program Flow Diagram

engine). The number and type of components in each line are described, with up to 23 line components currently being available. These components include straight and curved line sections, valves, bellows, venturi's and PVC's. (The program computes component weights and flow resistance coefficients and display total values for each line as part of the output data.) Engine flowrate, NPSP and thrust profiles during the startup transient are also input. In addition propellant tank geometry and propellant and vehicle weights are required, along with input data control flags and miscellaneous boundary conditions.

As illustrated in Fig. 1, the program will compute the various pressure drop components needed to evaluate tank pressure requirements during engine start. These calculations are performed for each candidate main feedline size (engine feedlines sizes assumed fixed) as a function of time throughout the start transient. Feedline weights are computed based on the maximum value of engine inlet pressure, the maximum value of tank bottom pressure, or an input design pressure, whichever is greatest.

The output data display consists of reformatted input data, feedline flow resistance coefficients, time-varying values of the pressure drop components due to hydrostatic head, flow acceleration, and line friction and configuration losses. Computed values of nominal and minimum required values of tank ullage pressure are displayed, as well as tank bottom and engine inlet pressures. Total feedline system weights are also output for each candidate main feedline size.

In summary, the present SOPSA capabilities are as follows:

- Performs pressure drop calculations for up to four engines per main feedline
- Handles up to 12 candidate main feedline sizes per engine

- Computes component weight and flow resistance for up to 100 components in each feedline
- Input options available to describe 23 types of components,
 7 material types, and 6 insulation types
- Operates on the UNIVAC 1108 computer utilizing the EXEC 8 operating system
- Approximate computer run time is 6 seconds per case

Section 1

SOPSA PROPELLANT FEED SYSTEM ANALYSIS PROGRAM

A major consideration in the design of propellant tanks and feed systems for the Space Shuttle Orbiter vehicle is the requirement that propellants be accelerated rapidly during the engine start sequence. Propellant tank structural design is influenced by the maximum ullage pressure levels required to provide sufficient flow acceleration, as well as hydrostatic pressure levels incurred during boost. Flow acceleration requirements, in turn, are dictated by pressure levels required to provide specified propellant flowrates at the engine during startup, while simultaneously satisfying minimum NPSP and inlet pressure requirements. Propellant feed system weights and flow resistance are influenced by component size and design pressure levels. Thus optimization of feed system design requires values of tank ullage pressure as a function of feedline diameter as well as feed system weight. The SOPSA program is designed to compute required pressure values and feed system weights for a range of main feedline diameters.

1.1 PROGRAM DESCRIPTION

Required values of propellant tank ullage pressures during engine start are determined by the pressures required to accelerate the propellant at the rate necessary to supply required flowrates at the engine. A proper accounting of the system pressure drops yields the following relation for ullage pressure requirement at any time during the start transient:

$$P_{u}(t) = P_{min} - \Delta P(t) + \Delta P_{F}(t) + \Delta P_{ACC}(t) + P_{TOL}$$
Head
$$P_{min} = Maximum \ value \ of \begin{cases} P_{NPSP} + P_{VAP} \\ or \\ P_{ENG} \end{cases}$$
(1)

where

 P_{NPSP} = Engine NPSP requirement

 P_{WAP} = Propellant vapor pressure at engine inlet

 P_{ENC} = Minimum engine inlet pressure

 ΔP_{HEAD} = Hydrostatic pressure at engine inlet due to vehicle acceleration

 ΔP_F = Pressure drop due to friction in main feedline and engine feedlines

APACC = Pressure drop required to accelerate propellant to meet the specified flowrate variation during startup

 $P_{TOT.}$ = Component pressure control tolerance

The pressure control tolerance is generally interpreted to be a combined tolerance on ullage pressure controls and engine inlet requirements.

Equation (1) is solved for an assumed feedline configuration employing a single main feedline for each propellant with up to four branching engine feedlines. This arrangement is illustrated schematically in Fig. 2. Feed systems employing dual main feedlines can be analyzed by restarts or separate runs. Currently, the program is restricted to consider liquid oxygen as the oxidizer and liquid hydrogen as the fuel. An input data flag (SYSNUM) is used to specify whether computations are to be performed for the oxidizer system, fuel system or both feed systems. A ground start flag (NGST) is used to distinguish between engine start on the ground ($g/g_0 = 1.0$) or at altitude ($g/g_0 = Total Thrust/Vehicle Mass$) for purposes of hydrostatic head computations.

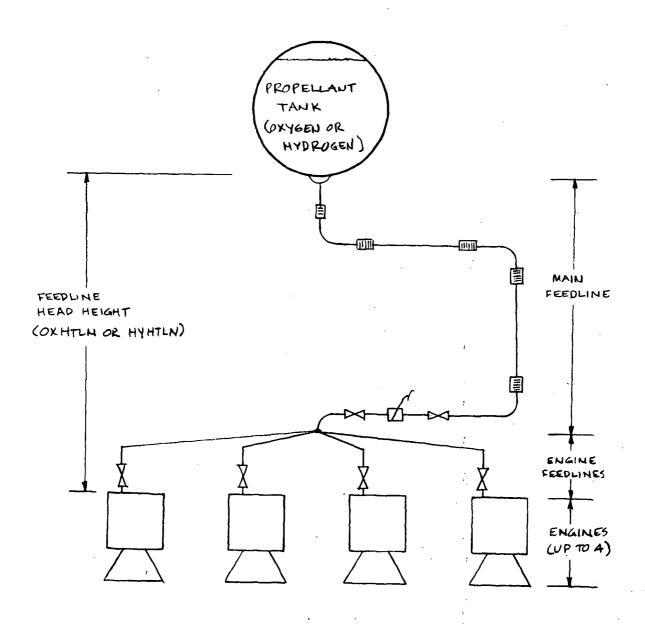


Fig. 2 Propellant Feed System Schematic

1.1.1 Feedline Configuration Description

It is assumed that a single main feedline (for a given propellant) supplies fluid up to four engine feedlines. The number of engine feedlines is denoted by the integer NEL (NEL = 1, 2, 3 or 4). The feedline components are numbered sequentially beginning at the propellant tank outlet; the type of component in the sequence is denoted by an identification number. The maximum number of components in each main feedline is 100. The maximum number of components in each engine feedline is also 100.

In addition to the identification number, each component may also require specification of material type as well as additional configuration data. Thus the component specification input data fields will generally include the following data:

- Identification Number
- Material Type Flag
- Insulation Type Flag
- Configuration Specification (1)
- Configuration Specification (2)

The types of components currently available, their identification numbers, and auxiliary specification requirements are listed in Table 1-1. The material and insulation flags are defined in Tables 1-2 and 1-3. Input data descriptions for components 3-8 are provided in Figs. 3 through 8.

1.1.2 Propellant Tank Configuration Description

Propellant tank geometry is described by nine linear dimensions, as shown in Fig. 9. It is assumed that the oxidizer tank is forward of the fuel tank, and that the tanks are cylindrical with spheroidal or ellipsoidal domes. It is also assumed that a single, common bulkhead separates the oxidizer tank from the fuel tank.

Table 1-1 FEEDLINE COMPONENT SPECIFICATIONS

	IDENTIFICATION			(-)		(0)
COMPONENT TYPE	NUMBER (TYPE FLAG)	M MATERIAL FLAG REQUIRED	INSULATION FLAG REQUIRED	SPECIFICATION (5)	SPECIFICATION (5)	SPECIFICATION (8)
	TITE PLACE			•		NO. 3
SUMP(6)	1	NO	МО	NA	NA	NA
STRAIGHT LINE SECTION	2	YES	YES	LENGTH	N A	INSULATION THICKNESS
CURVED LINE SECTION (BEND)	3	YES	YES	LENGTH	BEND RADIUS	INSULATION THICKNESS
COMPOUND "U" ELBOW ⁽¹⁾	14	YES	YES	LENGTH	BEND RADIUS	INSULATION THICKNESS
NINETY-DEGREE OFFSET BEND (1)	5	YES	YES	LENGTH	BEND RADIUS	INSULATION THICKNESS
"Z" BEND(1)	6	YES	YES	LENGTH	BEND RADIUS	INSULATION THICKNESS
GRADUAL EXPANSION	7	YES	YES	LENGTH	INLET/EXIT DIAMETER RATIO	INSULATION THICKNESS
CONTRACTION	8	YES	YES	LENGTH	INLET/EXIT DIAMETER RATIO	INSULATION THICKNESS
SINGLE LEG OF DIVERGING BRANCH (7)	9	-	-	~	-	-
VENTURI	10	YES	NO	LENGTH	THROAT DIAMETER/ INLET DIAMETER	INSULATION THICKNESS
FLOWMETER (7)	11	-	-	-	- 1	-
GATE VALVE(7)	12	-	-	-	-	-
BUTTERFLY VALVE, MEDIUM WEIGHT (2)	131	NO	NO	NA	NA	NA
BUTTERLY VALVE, HEAVY WEIGHT (3)	.132	NO	NO	NA	NA	NA
BUITERLY VALVE, EXTRA HEAVY WEIGHT (4)	133	NO	NO	NA	NA	NA .
POPPET VALVE, MEDIUM WEIGHT(2)	141	NO	NO	NA	NA -	NA NA
POPPET VALVE, HEAVY WEIGHT (3)	142	NO	NO	NA	NA	NA
POPPET VALVE, EXTRA HEAVY WEIGHT (4)	143	NO	NO	NA	NA	NA
BALL VISOR VALVE	15	NO	NO	NA	NA	NA
DISCONNECT	16	NO	NO	NA	NA	NA
U-PIN TIE ROD BELLOWS	17	NO	NO	NA	NA	NA
PIN OR HINGE JOINT BELLOWS	18	NO	NO	NA	NA	N A
EXTERNAL GIMBAL BELLOWS (W/O LINER)	19	NO	NO	NA	NA .	NA
EXTERNAL GIMBAL BELLOWS (WITH LINER)	20	NO	NO	NA	NA (NA
INTERNAL GIMBAL BELLOWS (W/O LINER)	21	NO	NO	NA	NA	NA
PRESSURE-VOLUME COMPENSATOR	22	NO	NO	NA	NA ,	NA
INTERNAL BALL-STRUT BELLOWS	23	NO	NO	NA Francis	NA NA	NA NA

NOTES:

- (1) CONFIGURATIONS DEFINED IN FIG. 3

- (2) MODULATION, SHUTOFF, FILL, ISOLATION VALVES
 (3) PRESSURE REGULATORS, FLOW CONTROLS AND MIX VALVES
 (4) SOLENOID AND BALL VALVES
 (5) ALL DIMENSIONS IN FEET, LENGTHS ARE TOTAL CURVILINEAR CENTERLINE LENGTHS
 (6) SUMP WEIGHT IS NOT COMPUTED
 (7) THIS OPTION NOT CURRENTLY IMPLEMENTED
 (8) INSULABION THICKNESS INDIES IN INCHES

- (8) INSULATION THICKNESS INPUT IN INCHES

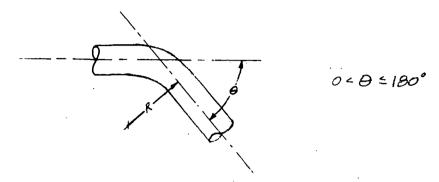
Page intentionally left blank

Table 1-2
COMPONENT MATERIAL FLAGS

MATERIAL FIAG	MATERIAL TYPE
1	321/347 Stainless Steel
2	2219-T87 Aluminum Alloy
3	6061-T6 Aluminum Alloy
4	Inconel-718 Alloy
5	Titanium TI-6AL-4V Alloy
6	CRES Vacuum Jacketed Line
7	2219 Vacuum Jacketed Line

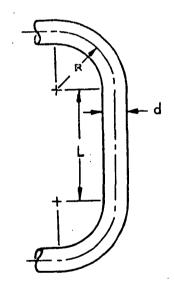
Table 1-3
INSULATION MATERIAL FLAGS

INSULATION FLAG	INSULATION TYPE
1	Double Alum. Mylar/Silk Net (50-60 L/In)
2	Double Gold Mylar/Silk Net (50-60 L/In)
3	NRC-2 Crink. Al. Mylar (40 L/In)
4	Superfloc (30 L/In)
5	Polyurethane Foam
6	Fiberglass Batting



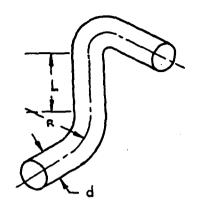
SPECI = LENGTH = $R \times \left(\frac{\theta}{57.3}\right)$, θ IN DEGREES, R IN FEET 5 PEC2 = BEND RADIUS = R, FEET

Fig. 3 Inputs For Curved Line Section



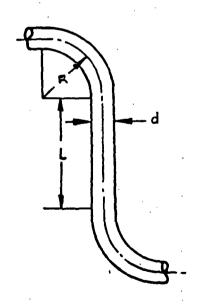
SPECI = LENGTH = L+TR; L,RIN FEET SPECZ = BEND RADIUS = R; FEET

Fig. 4 Inputs For Compound "U" Elbow



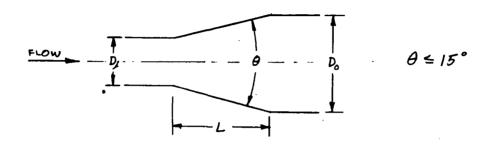
SPECI = LENGTH = L + TR; L,R IN FEET SPECI = BEND RADIUS = R, FEET

Fig. 5 Inputs for 90° Offset Bend



SPECT = LENGTH = L+TR; L,R IU FEET SPECT > DENO RADIUS = R, FEET

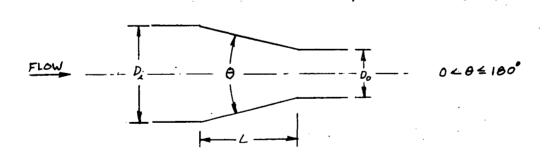
Fig. 6 Inputs for "Z" Bend



SPECT = LENGTH = L, FEET

SPECZ = Di/D.

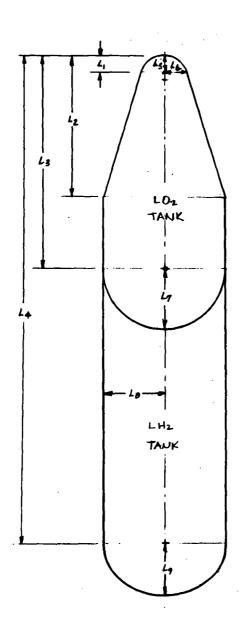
Fig. 7 Inputs For Gradual Expansion



SPECI = LENGTH = L, FEET

SPECI = D. / D.

Fig. 8 Inputs For Contraction



- HEMBPHERICAL, SPHEROIPAL OR ELLIPSOIRAL DOMES
- LO2 TANK FORWARD OF LH2 TANK
- COMMON BULKHEAD BETWEEN LOZ AND LHZ TANKS

GEOMETRY INPUT VIA VARIABLE EQLR(I), I=1,9.

EQLR(1) = L;

EQLR(2) = L2

:

EQLR (9) = L9

Fig. 9 Propellant Tank Configuration Definition

1.2 INPUT DATA

The input deck structure is designed so that several cases may be processed during one run. Also, only the data groups which vary from one case to the next need be input. The input data consist of two header cards followed by 16 input groups (I.G.'s). The data input sequence is as follows:

- Case Title Card (First Header Card)
- Input Data Flags (Second Header Card)
- Feed System Configuration Descriptions (I.G.'s 1-5)
- Fixed Input Data (I.G.'s 6, 7 and 8)
- Time-Varying Imput Data (I.G.'s 9-15)
- Restart Card (I.G. 16)

The overall organization of the input data deck is illustrated in Fig. 10.

The case title card contains an alphanumeric description whose contents are determined by the user. The input data flag card contains a series of 16 integer digits corresponding to the 16 input data groups. A one (1) in the position corresponding to a given input group indicates that data cards for that group are present in the data deck. A zero (0) indicates that data for that group are not present, so that data from a previous case are to be used in computations for the current case. Thus all the input data flags must equal to one (1) for the first case. (Note that for the final case in a run the value of the data flag for I.G. 16 must be equal to one (1) so that the program will read the restart card.) Both header cards (the title card and the data flag card) must be input for each case.

The input data describing the propellant feed system configuration include the number of main and engine feedline sizes to be considered, the number of engines on the vehicle, the number of time points for which transient start data will be input and the ground start flag. These are followed by data describing the tank and feedline configurations, as discussed in sections 1.1.1 and 1.1.2 above.

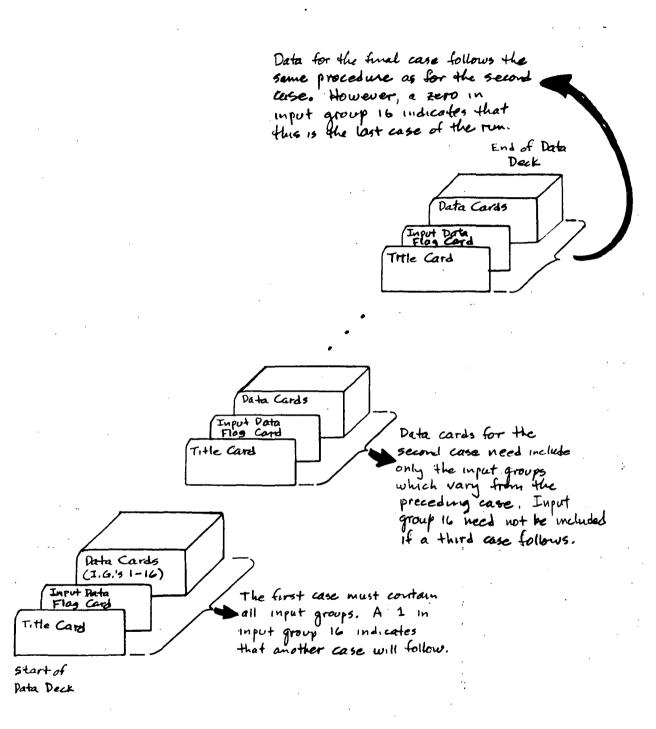


Fig. 10 Input Data Deck Organization

Fixed input data include values of loaded propellant masses, nominal (steady-state) values of propellant flowrates and engine thrust, propellant temperatures at the engine inlet and the liquid surface in the tank, and the engine inlet pressure tolerance.

Time-varying inputs are used to describe the variation of engine flowrate, thrust and NPSP requirements during the start transient. Additional inputs which are also time-dependent include data describing minimum engine inlet pressure requirements, partial-pressures of propellant tank pressurant gas, and pressurant gas inlet temperatures.

The definitions of input data quantities and input data formats are provided on the format sheets shown in Appendix A. The format for the title card is FORTRAN 7A6; the format for the input data flag card is FORTRAN 16I1; the format for the feedline configuration data is FORTRAN (3I6, 3E12.8). The formats for the remaining input data are either FORTRAN ((6E12.8)) for floating point data or FORTRAN ((12I6)) for integer data.

1.3 INPUT DECK SETUP

The input deck consists of a set of control cards, a set of input data, and an end-of-run (FIN) card. The set of input data cards is arranged as shown in Fig. 10. Thus, the deck setup for a complete run is as shown on Fig. 11. Use of the deck configuration shown in this figure assumes that the program deck has already been compiled and placed on a mass storage file under the name SØPSA. The control cards illustrated apply to usage on the UNIVAC 1108 computer operating under the EXEC 8 control system.

1.4 CONTROL CARDS

Control cards required to operate the SOPSA program consist of those cards necessary to assign and execute program storage files under the appropriate control system. The control statements required for operation on the UNIVAC

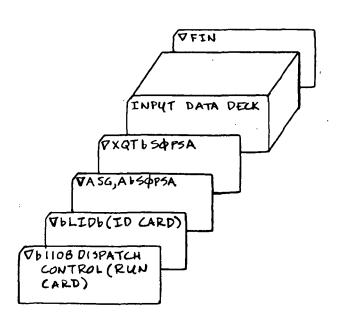


Fig. 11 Input Deck Setup

1108, EXEC 8 system have been described in Section 1.3.

1.5 OUTPUT DATA

Sample output data for SOPSA are shown in Table 2-4. An accompanying description of output quantities is provided in Section 2.2.

1.6 ERROR MESSAGES

No diagnostic error messages are currently provided in the SOPSA program.

1.7 RESTRICTIONS

Input data restrictions occur as a result of dimension limits on program variables and output data formatting limits. These limits apply primarily to descriptions of the feedline configuration and the propellant tank configuration, as described in Sections 1.1.1 and 1.1.2.

In addition, the number of time points used to describe transient input data is restricted to a maximum of 21 (cf. input groups 9-15, Appendix A).

Section 2 SOPSA DATA SAMPLES

In order to illustrate the application of the SOPSA program, a sample problem has been set up utilizing a feed system configuration typical of those designed for the external fuel tanks for the Space Shuttle orbit injection propulsion system. The feed system configurations are shown in Figs. 12 and 13. Corresponding lists of feedline components are given in Tables 2-1 and 2-2. Values of input data parameters required to describe these components are also listed. These parameters are obtained from the component characteristics listed in Table 1-1.

2.1 INPUT DATA LISTING

A listing of an input data deck for the feed system described above is shown in Table 2-3. For purposes of illustration each card has been labeled in columns 73-80. Definitions of individual input quantities can be obtained by referring to the input data formats given in Appendix A. It may be seen from Table 2-3 that a restart case has been added at the end of the first case (IGOON = 1 at end of first case). In the data for the second case only a single input group has been changed (I.G. 13) so that only new values of data for this group are provided (i.e., revised values of PENMNO) and PENMNH).

2.2 OUTPUT DATA LISTING

Output for the first case of the sample problem is listed in Table 2-4.

A listing of several of the fixed input data quantities is shown on the first page, along with computed values of tank surface areas and liquid head heights. Tank and feedline configuration input data are listed on the next three pages. The feedline data listing also includes computed values of line lengths and

flow resistance coefficients (K-factors). On the next page are listed values of time-varying input data quantities as defined in the input data formats.

Computed values of various significant transient feed system parameters are presented on the next page. These include the time derivative of propellant flowrates (WDDØT), total vehicle weight, thrust-to-weight ratio (always equal to one for a ground start), hydrostatic pressure head at the engine inlet (DELPHD), incremental propellant usage (PRØP-Ø-INCR and PRØP-F INCR), cumulative propellant used (PRØP-TØT CUM) and minimum inlet pressure requirements at the engine inlet (PENG ØXID and PENG FUEL). The latter quantities may differ from input values of PENMNØ and PENMNH if the sum of propellant vapor pressure plus engine NPSP is higher than these input quantities.

The next two blocks of output contain computed values of the increment in pressure required to accelerate the propellant to meet specified flowrate requirements (ΔP_{ACC}) for the main feedlines. This is followed by two similar output blocks displaying computed values of main feedline pressure drops due to line friction and configuration losses. The next two pages of output contain similar data for the engine feedlines.

This is followed by a printout of the nominal propellant tank ullage pressures required in the two feed systems. These pressure values reflect only the requirement implied by the solution of Equation (1), Section 1.1. Thus the nominal requirements may be less than the ullage pressure required to suppress propellant boiling, as shown in the output for the oxidizer tank.

The next output block contains a listing of several intermediate quantities. These include, in order,

- Propellant vapor pressure at the liquid surface (ULLVAP)
- Minimum ullage pressure required for main feedline No. 1 (MINUIL)
- Tank bottom pressure for feedline No. 1 (TNKBØT)
- Line head pressure components (LINHED)
- Tank Ullage Volumes (ULLVØL)

- Tank head heights (TNKHED)
- Ullage vapor weights

The nominal ullage pressure requirements are checked against the vapor pressure requirements in the propellant tank and revised, if necessary, to produce minimum required values of ullage pressure. These values are printed in the next two output blocks for oxygen and hydrogen feed systems, respectively.

Revised tank bottom pressures (based on minimum required ullage pressures) are output in the succeeding two output blocks.

The recomputed values of engine inlet pressures (using final minimum ullage pressure values) are then printed out.

The final output block contains a summary of total feedline and insulation weights for each of the candidate main feedline sizes. It should be noted that zero-values for insulation weights are shown for the hydrogen system, since a vacuum-jacketed feed system was specified.

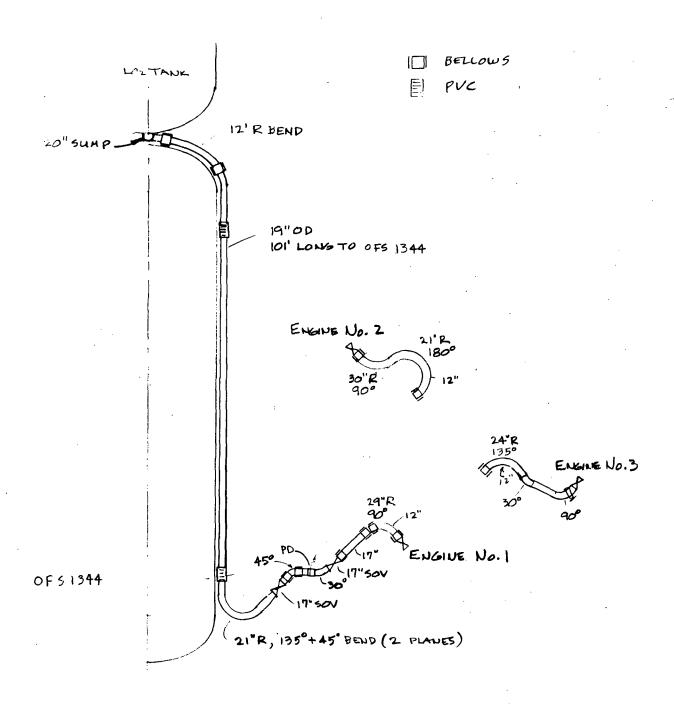


Fig. 12 Oxygen Feed System - Orbiter 040A

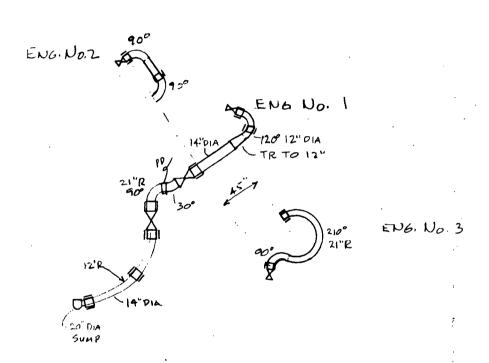


Fig. 13 Hydrogen Feed System - Orbiter 040A

Table 2-1
HYDROGEN FEED SYSTEM CONFIGURATION

SECTION	COMPONENT	ID	IM	II	SPEC1	SPEC2	SPEC3
Main Feed Line	Sump	1	_	-	-	-	-
	Straight Line	2	7	-	1.0	-	-
	Bellows	20	-	-	-	-	-
	Bend	3	7	_	9.44	12.0	-
	Bellows	20	-	_	5 /	-	-
	Bend	3	7	-	9.44	12.0	-
	Bellows	20	-	-	-	-	-
	Ball Visor Valve	15	_	-	-	-	-
	Bend	3	7	_	2.75	1.75	-
	Disconnect	16	-	_		-	-
·	Bend	3	7	-	0.92	1.75	-
	Ball Visor Valve	15		-	-	-	-
	Bellows	20	-	-	-	-	-
Main Feed Line	Straight Line	2	7	-	3 .7 5	-	-
Eng. Line No. I	Transition	8	7	-	i.0	1.35	-
	Bellows	20	-	_	_	-	-
	Bend	3	7	-	3.14	1.5	-
	Bellows	20	-	-	-	-	·_
Eng. Line No. 1	Ball Visor Valve	15	-	-	-	-	_
Eng. Line No. 2	Bend	3	7	_	2.35	1.5	_
	Compound Elbow	4	7	-	7.5	1.5	-
	Bellows	20	-		-		_
Eng. Line No. 2	Ball Visor Valve	15	-	_		-	-
Eng. Line No. 3	Bellows	20	-	_	-	_	_
	Bend	3	7	-	2.35	1.5	-
	Bend	3	7	_	9.15	1 .7 5	_
	Bend	3	7	-	5.49	1.75	_
·	Bellows	20	-	-	-	-	-
Eng. Line No. 3	Ball Visor Valve	15	-	-	-		-

Table 2-2
OXYGEN FEED SYSTEM CONFIGURATION

SECTION	COMPONENT	ID	IM	II	SPEC1	SPEC2	SPEC3
Main Feed Line	Sump	1	_			_	
	Bend	3	2	5	5.0	20.0	0.75
	Bellows	20	_	_		_	_
	Bend	3	2	5	9.16	13.33	0.75
	Bellows	20	_	_	_	_	_
	Bend	3	2	5	4.16	8.33	0.75
	Straight Line	2	2	5	7.0	_	0.75
	P VC	22	-	_	_	_	_
	Straight Line	2	2	5	72.0	_	0 .7 5
	PVC	22	_	· -	. –	-	-
	Straight Line	2	2	5	4.0	_	0.75
	Bend	3	2	5	4.1	1.75	0.75
	Bend	3	2	5	1.38	1.75	0 .7 5
	Straight Line	2	2	5	4.0	_	0.75
	Ball Visor Valve	15	_	_		_	-
	Bellows	20	_	_	_	_	-
	Bend	3	2	5	1.0	1.27	0 .7 5
	Bellows	20		-	_	-	-
	Straight Line	. 2	2	5	1.5	-	0.75
	Disconnect	16	-		. -	_	-
	Bend	3	2	5	4.0	7.65	0.75
	Ball Visor Valve	15	-	· -	-	- .	_
	Bellows	20	-	_	· <u>-</u>	_	-
	Straight Line	2	2	5	7.0	-	0.75
]	Bellows	20	_	_	_	_	-
Main Feed Line	Transition	8	2	5	1.0	1.5	0.75
Eng. Line No. 1	Bellows	20	-	-	-	- ·	-
	Bend	3	2	5	3.8	1.5	0.75
				İ			

Table 2-2 (Cont.)

OXYGEN FEED SYSTEM CONFIGURATION

SECTION	COMPONENT	ID	IM	II	SPEC1	SPEC2	SPEC3
Eng. Line No. 1	Bellows	20	-	-	_	-	_
	Ball Visor Valve	15	-	-	_	-	-
Eng. Line No. 2	Bellows	20	-	-	_	-	-
	Bend	3	2	5	5.5	1.75	0.75
	Bend	3	2	5	3.93	2.5	0.75
	Bellows	20	-	-	-	-	-
	Ball Visor Valve	15	-	_	-	-	-
Eng. Line No. 3	Bellows	20	_ :	-	_	-	-
	Bend	3	2	5.	4.71	2.0	0.75
	Bend	3	2	5	1.5	2.86	0.75
	Bellows	20	-	-	, -	-	-
Eng. Line No. 3	Ball Visor Valve	15	-	-	_	-	-
İ	Ĭ						

Table 2-3
SOPSA INPUT DATA LISTING

11111111		TO LIER	G40A+ LDW PE			•	TITLE
3		3	3 3 2	21 ?		•	NML + FT
143.	39.						TOTAL
120.	549.		551.	1691.	120.	120.	EQLR1
125	181.		128.				EQLR1
26	4	5	7				MIDLO
1				•			IDALO
3		55.	20.	<u>,75</u>			TOMIO _
50	_						IDMLO
3	. 2	59.15	13.33	.75			IDML O
20		F / A /					IDMLO
3 2	5 5	54.16	8.33	•75			TOMLO
<u>5</u> 2	2	57.		.75	•		IDMLO
5	5	572.					IDMLO IDMLO
55	•	312		• 1 3			IDMLO
2	2	54.		.75			IDMLO.
3		54.1	1.75	.75			IDMLO
ź	5	51.38	1.75	.75		<i>i</i> ,	IDHLO
<u>,</u>	ā	54.	• • •	75			IDHLO
15							IDMLO
20							IDMLD
	2	51	1.27_	75			IDMLQ
50							IDMLO
2	5	51.5		.75			IDMLO
16							IDMLO
3.	5	54.	7.65	.75		·	IDMLO
15							IOMLO
Sō							IDMLO
2	5	57.		•75			IDMLD
50	_	e 4					IDMLO
	2	51.	1.5	.75			IDMLO
20	2	67 0	4 2	4 4		:	IDEL01
3 20	<i>c</i>	53.8	1.5	.75			IDEL.01
50							IDEL01
15 20			•				IDELOS
~ U	5	55.5	1,75	.75		•	TOEFOS
	5	53,93	2.5	.75			IDELOS
20	_	2000	r • 3	• 7 3			IDEFOS
15							IDELOS
50		·					IDELO3
3	2	54.71	2.	. 75		-	IDELO3
3	Ş.	51.5	2.86	.75 .75			IDELO3
55	5	53.		.75			IDEL 03
2	5	53.8	1.5	.75 .75			IDEL03
50			<u> </u>				IDEL03
15							IDEL03
5.	12.		12.	12.	13.	14.	OPD
5.	16.		17.	18.	19,	20.	OPD
21.	22.	,	23.				OPD
1.4	5	4	6			*	MIDLH
1				·		 	IDMLH
2	7	1.					IDMLH
50	_		_				IDHLH
3		9.44	12,			·	I DML H
50	_					•	IDMLH
3	7	9.44	12.	•			IDMLH
20							IDMLH

Table 2-3
SOPSA INPUT DATA LISTING (CONT'D)

		20121. 111101	21.11. 210.	2110 (0011 2)		
3	7 2.79	1.75				IDMLH
16						IDMLH
	.92	1.75				IDMLH_
15					· · · · · · · · · · · · · · · · · · ·	IDMLH
20						IDMLH
2	_73.79	•				IDMLH
8	7 1.	1.35			·	IDELH1
20	,	1433				IDELH1
	7 3.14	1.5		•		IDELH1
20		·			·	IDELHI
15						IDELHI
	72.39	1.5				IDELH2
4	7 7.5	1.5				IDELH2
20	1 1.5	1.0				IDELH2
15						IDELH2
50						IDELHS
3	7 2.35					
3	7 2.35	1.5 51.75.				IDELH3
3						IDELH3.
2.0	7 5.49	1.75				IDELH3
15						IDELH3
12.	12.	12.	4.3		4.0	IDELH3
15.			12.	13.	14.	нрр
21	16.	17.	18.	19.	20.	н <u>Р</u> Б
99.5	22.	53•				HPD
	-9.5	5547354	•		•	HTLN
1743858.	290643.	5503250.				LOAD
894.	149	470000.				WDOT • F
162.9	37.	168.	38.5	3.		TENIN
0.	• 2	. 4	• 6	<u>.</u> 8	1.	TIMEA
1.2	1 • 4	1.6	1.6	2	2.2	TIMEA
2.4	2.6	2.8	3.	3.2	3.4	TIMEA
3.6	3.8	4.				TIMEA
0.	0	.005	01	50.	.085	WOTERD
.082	.08	.08	•1	•17	.318	WOTERO
.466	.614	.762	•91	1.01	1.02	WOTERO
1.02	1.02	1.02				WDIERQ
0.	•006	.013	.026	.047	.081	WDTFRH
•165	.263	.246	.26	.294	.42	WOTERH
51		. 893	996	• 999	1	WOTERH
1.	1.	1.				WOTERH
0.	0.	.005	.01	.02	.085	FIFRAC
	08	. 08	1	17	318	FIFRAC
.460	.614	.762	.91	1.01	1.02	FIFRAC
1.02	1.02	1.02			_	FIFRAC
8	8		8	<u> </u>	<u>B.</u>	NPSPO
8.	8.	8.	8.	8.	₿.	NPSPO
8.	8.	8.	8,	8.	8.	NPSPO
8	<u> 8</u>	<u>8.</u>				NPSPO
2.	2.	2.	۶.	s.	2.	NPSPH
ž.	2.	2.	2.	2.	5•	NPSPH
<u> </u>	2	?		2.	2	NPSPH
2.	5.	2.				MPSPH
2 5•.	25.	25.	25.	25.	. 25.	BENWNO
4 25	. 25	25	25	25	25	PENHNO
- 25.	25.	25.	25.	25.	25.	DENHNO
25.	25.	25.				PENMNO
3 20.	20.	50.		20.	20.	PENMAH
20.	20.	20.	20.	20.	20.	БЕИМИН
20.	20.	20.	20.	20.	20.	PENMNH
£20 •		20.				PENMNH
0.	0.	0.	0.	0.	0.	PPDGOT
					A COLOR OF THE COL	

Table 2-3
SOPSA INPUT DATA LISTING (CONT'D)

0.	0.	0.	0.	0.	0.	PPDGDT
0.	0.	0.	0.	0.	0.	PPNGCT
.0	0	0.				PPDGCT
0.	0.	0.	0.	0.	0.	PPDGHT "
0.	0.	0.	0.	C •	0.	PPDGHT
0		0	Q.	0.	0 •	PPOGHT
0.	0.	0.				PPDGHT
190.	190.	100.	190.	190.	190.	TOGOT
190	190	199.	190.	190.	190	TOGOL
170.	190.	190.	190.	190.	190.	TOGOT
190.	190.	190.				TOGOT
60	60	60.	50	60.	50.	TOGHT
60.	60.	60.	60.	60.	60.	TOGHT
60.	60.	60.	60.	60.	60.	TDGHT
60.	60	60				TOGHT
1						IGOON
SAMPLE	CASE - ORBIT	TER 040A. HIG	Н РЕИМИ			TITLE
	00001001			<u> </u>		DATAELG
60.	60.	60.	60.	60.	60.	PENMNO
60.	60.	60.	60.	60.	60.	PENMNO
60.	60.	60.	60.	60.	60.	PENMNO
60.	60.	60.				PENMNO
30.	30.	30.	30.	30.	30.	PENMNH
30,	30	30	30	30.	30.	PENMNH
30.	30.	30.	30.	30.	30.	PENMNH
30.	30.	30.	- · ·			PENMNH
	- • •					TGOON

Table 2-4 SOPSA OUTPUT DATA LISTING

SAMPLE CASE - ORBITER 040A LOW PENMN

INPUT JATA FOR START TRANSIENT FROBLEM CONSIDERED IN THIS ANALYSIS.

	NUMBER OF LINE SIZES TO BE CONSIDERED IS 15	
THE	PROBLEM CONSIDERS BOTH OXIDIZER AND FUEL FEED SYSTEMS	
THE	NUMBER OF ENGINES FOR THE VEHICLE IS 3	
THE	NUMBER OF ENGINES FOR EACH FEED SYSTEM IS 3	
THE	NOMINAL OXIDIZER FLOW RATE IS 894,00 LBS/SEC	•
	NOMINAL FUEL FLOW RATE IS 149,00 LBS/SEC	
	VEHICLE LOADED WEIGHT IS \$503250,00 LBS	
	NOMINAL THRUST FOR EACH ENGINE 15 470000,00 LBS	*
	BULK OXID, ENGINE INLET TEMPERATURE IS 162,90 DEG.R.	
	BULK FUEL ENGINE INLET TEMPERATURE IS 37,00 DEG.R	
	COMPONENT PRESSURE TOLERANCE IS 3.00 PSI	
	OXID. HEAD HEIGHT IN THE TANK IS 51,784 FT	
THE	OXID. HEAD HEIGHT IN THEFEED LINE IS 99.500 FT	
THE	FUEL HEAD HEIGHT IN THE TANK IS 96,186 FT	
THE	FUEL HEAD HEIGHT IN THE FEED LINE IS 49,500FT	
THE	INITIAL ULLIAGE VOLUME IN THE OXIDIZER TANK IS 608, CU.FT	
	INITIAL ULLAGE VOLUME IN THE FUEL TANK IS 1784. CU,FT	
	INITIAL OXIDIZER LOADING IS 1743858, LBS	
THE	INITIAL FUEL LOADING IS 290643, LBS	%
THE	EXTERNAL SURFACE AREA OF THE DROP TANK IS 13653.1 Sq. FT.	
	EXTERNAL SURFACE AREA OF THE LOX/LH2 BULKHEAD IS 1160.2 SO. ET.	
	TOTAL SURFACE AREA IS THEREFORE 14813,4 SQ, FT.	•
	OXYGEN FEEDLINE DESIGN PRESSURE IS .00000000 PSI	
THE	HYDROGEN FEEDLINE DESIGN PRESSURE IS 00000000 PSI	

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

THE TANK GEOMETRY INPUT VALUES ARE AS FOLLOWS - .

L1= 120,000 L2= 549,000 L3= 551,000 L4=1691,000 R1= 120,000 R2= 120,000 R3= 128,000 R4= 181,000 R5= 128,000

	OXIDIZER L		FEED LINE DATA	FUEL LINES		•
DIAMETER INCHES	LENGTH FEET	K=FACTOR	DIAMETER INCHES	LENGTH FEET	KOFACTOR	
12,00	6.80	,4143	12,00	7,14	14073	
12,00	12,43	5499	12,00	11.85	6388	
12,00	16.01	6353	12.00	19.99	8469	
12,00	143.00	3,0925	12,00	39.00	1,4212	
13,00	143,00	2,9399	13,60	39.00	1,3822	
34.00	143.00	2,6095	14.00	39.00	1,3493	
15,00	143,00	2,6970	15,00	39.00	1,3214	
16,00	143,00	2,5991	16.00	39.00	1,2975	
17,00	143,00	2,5133	17.00	39,00	1,2769	
18,00	143,00	2,4375	18.00	39.00	1,2591	
19,00	143,00	2,3702	19:00	39.00	1,2436	
20,00	143,00_	2,3601	20.00	39,00	715705	
21,00	143,00	2,3063	51.00	39:00	1,2185	·
22,00	143.00	2,2579	22,00	39.00	1,2083	
23.00	143.00	2,2142	23,00	39,00	1,1994	

COMPONENT	DESCRIPTORS	FOR	MAIN	OXYGEN	FEEDI INC
COLL GIATIAL	DESCUTLIONS	, or		VAIDEIN	1 CEULINE

COMPONENT	TYPE	MAT	INSUL	SPEC1	SPEC2	SPEC3	
i .	. \$	0	0	.0000	.0000	.0000	
2	3	2 `	5	5,000	20,00	7500	· · · · · · · · · · · · · · · · · · ·
3	50	0	0	0000	.0000	.0000	
4	. 3	2	5	9,160	13,33	.7500	
5	20	0	ָּס י	0000	0000	0000	
6		2	5	4,160	8,330	7500	· ·
7	2	2	5	7,000	.0000	7500	
8	22	0	0	0000	.0000	0000	
9	2	2	5	72.00	.0000	7500	
10	22	٥	0	0000	.0000	,0000	
11	2	2	5	4,000	0000	7500	
12	3	2	5	4,100	1.750	7500	
13	3	2	5	1,380	1.750	7500	·
14	2	2	5	4.000	0000	7500	
15	15		0	0000	,0000	0000	
16	20	ŏ	Ŏ	0000	0000	0000	
17	3	2	5	1,000	1.270	7500	
18	20		0	0000	0000	0000	
19	- 2	ž	5	1,500	,0000	7500	
Ž'n '	16	ō	Ó	0000	.0000	0000	
21		2	5	4,000	7.650	7500	
22	15	ñ	ō	0000	.0000	0000	
23	20	ň	ň	0000	0000	0000	· · · · · · · · · · · · · · · · · · ·

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

		TYPE		INSUL	SPEC1	SPEC2	SPECS	
		COMPONEN	T_DESC	RIPTORS	FOR ENGIN	E HYDROGE	N FEEDLINE NUMB	ER 1
	14	2	7	. 0	3,750	.0000	.0000	
	13-	20	<u>Q</u>	0 .	.0000			
	12	15	Ö	ŏ	0000	,0000	.0000	`
_	11		. 7		9200	1.750	.0000	
	10	16	ń	0	0000	0000_		
	H	15 3	0 7	0		· 0000	.0000 .0000	
	. 7		🗓 📖	Q	.0000	, 0000	0000	
	6	3	7	0			.0000	-
	5	. 20	0	0	•0000	.0000	.0000	
	- 4		J̄	ā	9.440	12.00	0000	
	ŝ	20	Ö	Õ	,0000		,0000	
	2	2	7	0	1.000	.0000	,0000	
	<u> </u>	1	. 0	0	.000			
	COMPONENT	TYPE	MATLI	INSUL	SPEC1	SPEC2	SPEC3	
		CUMPONE	NI DES	CHILINK	P PUR MAIN	HYDROGEN	PEEDLINE	
	7	15	UT 0-6					
	6	20	0	ō	.0000	.0000	.0000	
	5	3	2	5	3,800	1.500	.7500	
	4	2	2	5	000	0000	7500	
	3	3	2	5	1,500	2,860	.7500	
	2	- 3	2	5	4.710	2.000	,7500 ,7500 ,7500	
	. 1	20	Ω	D				
	COMPONENT	TYPE	MAT	INSUL	SPEC1	SPEC2	SPE C3	
		COMPONEN	T DESC	RIPTORS	FOR ENGIN	IE: OXYGEN I	FEEDLINE NUMBER	3
		15	0 .		0000			
	4	20	0	0	0000	.0000	.0000	
	3	3	2	5	3,930	2,500	,7500 .0000	
	3		2	5	5.500	1.750	7500	
	Ĩ	20		0	.0000	.0000	.0000	·
	COMPONENT	TYPE	.MATLL	INSUL	SPEC1	SPEC2	SPEC3	
	(COMPONEN	T DESC	RIPTORS	FOR ENGIN	E OXYGEN I	FEEDLINE NUMBER	2
	4	15	0	0	,0000	.0000	.0000	
	3	20	0	0	.0000	.0000	0000	
		3	2	5	3.800	1.500	.0000 7500	
	ĩ	26	0		0000	0000	0000	
	COMPONENT	IYPE_	_MAILL	INSUL	SPEC1_	SPEC2	SPEC3	
		COMPONEN	T DESC	RIPTORS	FOR ENGIN	E OXYGEN	FEEDLINE NUMBER	1
	26	8	2	0 5	.0000 1.000	.0000 1.500	7500	
	25	20	n	n	. 1101110	, non	.0000	

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

~		_	_			
1		7		1 • 000	1.350	
2	20	0	0	,0000	.0000	.0000
3	3	7	ŋ	3,140	1,500	,0000
4	20 .	0	0	0000		
5	15	. 0	0	0000	.0000	.0000
Cı	OMPONES	T_DESC	RIPTORS	EOR ENGIN	E HYDROGEN	FEEDLINE NUMBER 2
COMPONENT	TYPE	MATL:	INSUL	SPEC1	SPEC2	SPECI
ī	3	7	0	2,350	1,500	0000
2	4	7	0	7,500	1,500	.0000
3	20	0	٥	0000	.0000	0000
4	15	0	ō	.0000	.0000	.0000
	OMPONEY	T.DESC	RIPTORS	FOR ENGIN	E HYDROGEN	FEEDLINE NUMBER
COMPONENT	TYPE	MATL	INSUL	SPEC1	SPEC2	SPEC3
ī	20	0	0	.0000	.0000	.0000
2	5	7	Ö	2,350	1.500	.0000
	3	7	Õ	9,150	1.750	
4	3	7	ō	5,490	1,750	0000
Š	20	'n	ŏ	.0000	.0000	.0000
á	15	ň	ŏ	0000	0000	0000

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

THE TIME DEPENDENT PERFORMANCE CHARACTERISTIC INPUT VALUES ARE AS FOLLOWS - .

TIME	NP\$P0	N⊇SPH	WDTFRO	WDTFRH	FIFRAC	PENMNO	PENMNH	PPDGOT	PPDGHT	TOGOT	TDGHT_
.00	8.00	2,00	.000	.000	,000	25,00	20,00	.00	,00	190,00	60.00
, 20	8,00	2.00	.000	.006	.000	25,00	20,00	.00	00	190,00	60,00
,40	8.00	2,00	005		005	25,00	20.00	00	00	190.00	60.00_
,60	8.00	2,00	.010	.026	.010	25,00	23,00	,00	,00	190,00	60,00
,80	8.00	2,00	•050	.047	.020	25,00	20,00	.00	00	190,50	60.00
1.00	8 : 00	2 , 00		081	085	25.00	20,00	00	00	190,50	60,00_
1,20	8,00	2.00	.082	,155	.082	25,00	20,00	,00	,00	190,00	60,00
1,40	8.00	2,00	.080	,263	.080	25,00	20,00	,00	,00	190,õQ	60,00
1.60	B.00	2,00	080		080	25,00	21.00	00	00	190.00	60,00
1,80	8.00	5.00	.100	.260	.100	25,00	20,00	,00	.00	190,00	60,00
2,00	8.00	2.00	1170	.294	. <u>1</u> 70	25,00	20.00	,00	,00	190.00	.60,00
2 , 20	8 • 00	2.00	,318	420	318	25.00	2🤊 , 00	,00	, 00	193,00	60.00_
2,40	8.00	2.00	. 1466	510	.466	25,00	27:00	,00	,00	190,00	60,00
2.60	8.00	2,00	:614	.730	614	25.00	55.00	.00	.00	190,00	60.00
-2.80-	8.00	2,00	762	893	762	25,00	20,00	0.00	,00	190.00	60.00
3,00	8,00	2,00	1910	,996	.910	25,00	20,00	,00	,00	190,00	60.CD
2.50	8.00	2,00	1.010	999	1.010	25.00	50.00	*00	• 00	190,00	60,00
3,40		2.00	1.020	\$.000	1.020	25.00	20.00	00		193.00	60.00_
3,60	8,00	5.00	1.020	1,000	1.020	25,00	20.00	• 00	• 00	190,00	60,00
3,80	8,00	2.00	1.020	1.000	1.020	25,00	20.00	• 00	,00	190.00	60,00
4.00	8.00	2.00	1.020	1.000	1.020	25,00 _	20,00	00	.00	190,00	6CQQ

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A. LOW PENMN

						•					
TRANS.	WoDOT	VDJOT FUEL	VEHICLE WEIGHT	T/W RATIO	DELPHD_	DELPHD FUEL	PROP-0	PROP+F	PROP-TOT	PENG	PENG FUEL
·											
.00	,000	4,470	5503249,75	1,000	74,49	2,65	1030	268	,268	25,00	20.00
	22,350	5,215	5503247,56	1,000	74,49	2,65	1,341	,849	2,458	25,00	20.00
.40	22,350	9,685	5503241,81	_1.000_	74,49	2,65	4,023	1,743	8,,225_	25.00	20.00
.60	44.700	15,645	5503230,56	1,000	74,49	2,65	8,046	3,263	19,534	25,00	2ñ.00
80	290,550	25,330	5503196,69	1.000	74,49	2,65	28,161	5,722	53,416	25,00	20.00
1.00	-13,410	62,580	5503140.94	_1.000_	74,48	2,65	44,789	10,996	109.202	25,00	20.00
1,20	-8,940	73,010	5503078,37	1,000	74,48	2,65	43,448	19,132	171.782	25,00	20,00
_1.40	.000	r12,665	5503012,75	1.000	74,48	2,65	42,912	22,752	237,446	25.00	20.00
1,60	89,400	10,430	5502941,87	1.000	74,48	2,65	481276	22,618	308,341	25,00	20,00
1,80	312,900	25,330	5502844,75	1.000	74,48	2,64	72,414	24,764	405,518	25,00	2ñ.00
2.00	661,560	93,870	5502682,00	1.000	74,47	2,64	130,832	31,916	568,316	25,00	20,00
2,20	661,560	67,050	5502430,19	1.000	74,47	2,64	210,269	41,571	820,156	25,00	20,00
2,40	661,560	141,550	5502086,50	1,000	74,46	2,64	289,656	54,087	1163.899	25.00	20.00
2.60	661,560	143,785	5501646,25	1.000	74,45	2,64	369,043	71,207	1604,149	25,00	20.00
2,80	661,560	76,735	5501113,44	1.000	74,43	2,64	448,430	84,438	2137,018	25,00	20,00
3,00	447,000	2,235	5500509,37	1.000	74,42	2,64	514,944	89,176	2741,138	25.00	20.00
3.20	44,700	,745	5499875,62	1.000	74,40	2,64	544,446	89,355	3374,939	25,00	20.00
3,40	.000	.000	-		74.39	2,64	547,128	89,400	4011,467	25,00	20.00
3,60		•				2,64	547,128	89,400	4647,995	25,00	20.00
3.80	,000	.000	5498602,62	1,000	74,37						
	.000	,000	5497966,12	1,000	74.35	2,64	547,128	89,400	5284,523	25,00	20,00

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE * ORBITER 0404: LOW PENMN * OXYGEN SUPPLY SYSTEM

DELTA-P TO SUPPLY ACCELERATION HEAD

DELTA TIME	12+0 INCH MAIN LINE	13.0 INCH MAIN LINE										
100	•000	.000	.000	.000	.000	.000	1000	.000	,000	000	:000	,000
,40	2.635	2,245	1,936	1,686	1,482	1,313	1,171	1,051	,949	,860	.784	,717
,60	2.635	2+245	1,936.	1,686	1,482	1,313	1,171	1,051		860	784	.717
	5.270	4,491	3,872	3,373	2,965	2,626	2,342	2.102	1,897	1.721	1.568	1,435
1,00	34.257	29,189	25,168	21,924	19.269	17:069	15,225	13,665	12,332	11.186	10.192	9,325
	1.581	-1,347_	<u>=1,162</u>	-1,012		7.88	703	<u>•</u> ,63 <u>1</u>	P.569	516	w 470	-,430
1,20	#1:054	-,898	-,774	-,675	■. 593	-,525	- 1408	-, 420	-,379	#,344	-:314	-,287
	•000	,000	,000	.000	.000	,000	,000	,000	,000	.000	:000	.000
1.60	10,541	8,981	7.744	6,746	5.929	5,252	4,685	4,205	3,795	3,442	3:136	2,869
1,80 2,00	36.892	31,435	27,104	23,611	20.752	18,382	161396	14,716	13.281	12,046	10.976	10.042
	78.000	66,462	57,306	49,920	43.875	38,865	34,667	31,114	28,080	25,469	23:207	21,233
2,20	78:000	66,462	57.306	49,920	43,875	38.865	34,667	31,114	28,080	25,469	23.207	21,233
2,40	78.000	66,462	57,306	49.920	43,875	38,865	34,697	31,114	28.080	25,469	23:207	21,233
2,60	78,000	66,462	57,306	49,920	43,875	38,865	34,667	31,114	28,080	25,469	23.207	21,233
2,80	78.000	66,462	57,306	49.920	43.875	38.865	34,667	31,114	28.080	25,469	23,207	21,233
3,00	52.703	44,907	38,720	33,730	29,645	26.260	231424	21,023	18,973	17,209	15,680	14,346
3,20	5.270	4,491	3,872	3,373	2,965	2,626	2,342	2,102	1,897	1,721	1.568	1,435
3,40	.000_	000	000	000	.000	.000	000	.000	.000	000	:000	.000
3,60	.000	,000	,000	,000	,000	,000	,000	.000	.000	.000	:000	,000
3,80. 4,00	•000	,000	,000	.000	.000	,000	1000	,000	.000	.000	:000	,000

LMSC-D991396

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A LOW PENMN	HYDROGEN SUPPLY SYSTEM

DELTARP TO SUPPLY ACCELERATION HEAD

DELTA TIME	12:0 INCH MAIN LINE	13.0 INCH Main Line	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH Main Line	22.0 INCH MAIN LINE	23.0 INCH
,00	1144	,122	,106	.092	.081	.072	1004	,057	.052	.047	:043	,039
20	.168	,143	,123	.107	.094	.084		,067				
,40	311						• •	.124				
,60	503	.429	,370		.283	,251	1224	,201				
, 60	1814	,694	,598	,521	.458	406	1302	,325	,293	,266	.242	,222
1.00	2.012	1,715_	1:478	1.288	1.132	1.003	1894	.803	724	1657	599	.548
1,20	2,348	2,000	1,725	1,503	1.321	1.170	1,043	,936	.845	,767	:698	,639
	407	-,347	•1299	-,261	•,229	-,203	-,181	•,162	P.147	-,133	121	··.111
1,60	,335	.285			189	1167	1149	,134	121	.110	100	.091
1.80	.814	,694	,598	,521	, 458	,406	1362	, 325	.293	. 266	242	,222
2.00	3,018	2,572	2,218	1.932	1,698	1.504	1,342	1,204	1.087	,986	.898	,822
2,20	2,156	1,837	1,584	1.380	1.213	1.074	1958	,860	776	1704	. 641	,587
2:40 _2:60_	4.552	3,878	3,344	2,913	2,560	2,268	2,023	1,816	1,639	1,486	1:354	1,239
	4.623	3,940	3,397	2,959	2,601	2,304	2,055	1,844	1,664	1.510	1.376	1,259
2,80	2,467	2,102	1,813	1.579	1,388	1,229	1,097	,984		,806	:734	,672
3,00	.072	.061	053	.046	.040	, 036	1,032	, 029	,026	, 023	:021	.020
3.20	•024	.020	,018	.015	.013	.012	1011	,010	.009	,008	.007	.007
3,40	•000	.000	,000		.000	000		,000	.000	.000	.000	.000
3.60	•000	,000	,000		.000	,000	1000	.000	.000	,000	:000	.000
3.80 4.00	•000	.000	,000	.000	.000	.000	1000	.000	.000	.000	:000	.000

IMSC-A991396

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

<u> SAMPLE CASE = ORBITER 0404, LOW PENMA - OXYGEN SUPPLY SYSTEM</u> DELTA-P QUE TO LINE FRICTION AND CONFIGURATION LOSSES DELTA 12.0 INCH 13.0 INCH 14.0 INCH 15.0 INCH 16.0 INCH 17.0 INCH 18.0 INCH 19.0 INCH 20.0 INCH 21.0 INCH 22.0 INCH 23.0 INCH MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE TIME .00 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 .0000 ___.20... .3431-03 .2368-03 .1682-03 .2728+04 .2217-04 .1820-04 140 <u>.,1514+02....1103=02....8211+03....6230+03....4407+03....3766+03....3054+03....2455+03....1996+03....1638+03</u> 160 .1235-01 .8525-02 ,6057=02 .4412±02 ,3285=02 ,2492=02 ,1923=02 ,1506=02 ,1222=02 ,9821=03 ,7983+03 ,6553=03 , 80.. .1513+00 .1044+0n 1,00 <u>.3a27±no....2642+nn</u>. <u>.1877+00__.1367+00__.1018+00__.7723=01__.5959=01__.4667=01__.3786+01__.3043=01__.2474+01__.2031=01</u> 1,20 .3602+00 .2486+00 .1766+00 .1287+00 .9578+01 .7267+01 .5007+U1 .4392+01 .3562+01 .2864+01 .2328+01 .1911+01 --- 1,40... .1723+00 .1255+00 .9343-01 .708P-01 .5470-01 .4284-01 .3475-01 .2794-01 .227i-01 .1864-01 .3513+00 .2425+00 1,60 <u>.2180+00....1588+00....1182+00....8972+01...6923+01...5422+01...4398+01...3536+01...2874+01...2359+01</u> <u>.4446+00.....3069+00.</u> 1,80 .4906+00 .3574+00 .2660+00 .2019+00 .1558+00 .1220+00 .9895-01 .7955-01 .6466-01 .5308-01 .1000+01 .6905+002.00 .3268+01 .2256+01 ,16D3+D1 ,1167+D1 ,8691+DQ ,6594+DQ ,5Q88+DQ ,3986+DQ ,3233+DQ ,2599+DQ ,2112+QQ ,1734+DQ 2:20 <u>.4137+01 .3013+01 .2243+01 .1702+01 .1213+01 .1029+01 .8343+00 .6707+00 .5452+00 .4475+00</u> <u>.8435+01</u>....5822+01... 2.40 .1601+02 .1105+02 .7850+01 .5718+01 .4257+01 .3230+01 .2492+01 .1952+01 .1583+01 .1273+01 .1035+01 .8493+00 ---2.60-.2598+02 .1793+02 ,1274+02 ,9282+01 ,6910+01 ,5243+01 ,4045+01 ,3169+01 ,2570+01 ,2066+01 ,1679+01 ,1379+01 2,80 <u>. 1881+02 1371+02 1020+02 7741+01 5973+U1 .4679+01 .</u>3795+0<u>1 .</u>3051+0<u>1 .248</u>0+01 <u>.2035+01</u> _383<u>7+02</u>___2648+02 3.00 ,5059+02 ,3492+02 .2481+02 .1807+02 .1345+02 .1021+02 .7877+J1 .6170+01 .5004+01 .4023+01 .3270+01 .2684+01 3,20 .2773+02 .2020+02 .1504+02 .1141+02 .8805+J1 .6897+01 .5594+01 .4497+01 .3055+01 .3000+01 .5655+02 .3903+02 3.40 .5711±02 __.3942+02 3,60 .2801+02 .2040+02 .1519+02 .1152+02 .8892+01 .6965+01 .5649+01 .4541+01 .3097+01 .5711+02 .3942+02 3.80 10+0305. 10+17695. 10+0404. 10+0405. 10+05+01. 1152+02. 1152+02. 1593+01. 2040+01. .5711+02 .3942+02

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE	ORBITER DADA, LOW PENMN	- HYDROGEN SUPPLY SYSTEM	

DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES

TIME	12.0 INCH MAIN LINE	MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH	19.0 INCH MAIN LINE	MAIN LINE	MAIN LINE	MAIN LINE	MAIN LINE
,00	.1017-03	,7183-04	,5213-04	13874=04	.2938-04	,2269=04	,1780-04	.1416=04	.1141-04	,9299-05	,7655-05	.6361-05
20	.1020-02	,7202-03	,5227+03	.3885=03	.2946=03	,2275-03	11785-03	,1420=03	,1144-03	,9325=04	7677-04	.6379+04
140	4298-02	_,3035=02	2202#02	1637.=02.	1241-02	.9586-03	7521-03	,5984 <u>=03</u>	4821-03	,3929=03	3234=03	2688-03
	.1506-01	,1063-01	.7717+02	ı5734±02	.4349-02	,3359-02	,2035-02	,2096=02	,1689-02	.1376-02	,1133-02	,9416-03
-	,4629-01	,3269-01	2372=01	1763=01	1337=01	.1033-01	,8101-02	.6446=02	,5193-02	,4232-02	,3484-02	,2895+02
1,00	1710+00	.1207±05	8763=01	6512=01	4939-01	3814-01		,2381=01	1918-01	1563=01	1287-01	1069-01
1,20	.5176+00	,3655+00	2653+00	•1971+00	1495+00	,1155+00	,9058-01	.7207-01	,5806-01	.4732-01	,3895-01	,3237=01
	,7321+00	,5169+00	,3752+00	.2788+00	,2115+00	,1633+00	,1281+00	.1019+00	.8212-01	,6692=01	,5509-01	,4578+01
1,60	.7235+n0	.5108+0n	3707+00	2755+00	2090+00	1614+00	1266+00	1007+00	8116-01	6613-01	5445-01	4524#01
1,80 2,00_	.8672+00	.6123+00	,4444+00	:3303+00	2505+00	,1934+00	,1518+00	.1207+00	,9728-01	.7928=01	,6526-01	,5423+01
	,1440+01	,1017+01	,7382+00	.5486+00	.4161+00	,3213+00	,2521+00	.2006+00	.1616+00	.1517+00	,1084+00	,9008-01
2,20	.2444+C1	1726+01	1252+01	19307+00	.7059+00	5451+00	14277+00	3403+00	2742+00	,2234+00	1839+00	1528+00
2,40	4137+01	2921+01	.2120+01	·1575+01	+1195+01	,9225+00	,7239+00	.5760+00	4641+00	.3782+00	,3113+00	.2587+00
	.7170+01	,5063+01	,3675+01	12731+01	.2071+01	,1599+01	,1255+01	,9983+00	.8044+00	,6555+00	,5396+00	,4484+00
2,80	1008+02	7119+01	,5167+01	.3840+01	2912+01	2249+01	11764+01	,1404+01	1131+01	.9217+00	7585+00	6305+60
3,00 3,20	.1125+02	,7941+01	,5763+01	,4283+01	3248+01	,2508+01	+1968+01	.1566+01	,1262+01	.1028+01	.8463+00	.7033+00
	.1129+02	7973+01	,5766+01	•4300+01	,3261+01	,2519+01	11976+01	.1572+01	.1267+01	,1032+01	.8497+00	.7061+00
3,40	,1130+02	7981+01	,5792+01	.4304+01	3265+01	2521+01	1978+01	1574+01	1268+01	,1033+01	8506+00	,7068+00
3,60	.1130+02	7981+01	,5792+01	·4304+01	,3265+01	,2521+01	11978+01	.1574+01	,1268+01	,1033+01	.8506+00	.7068+00
4.00	.1130+02	,7981+01	,5792+01	4304+01	,3265+01	,2521+01	11978+01	,1574+01	,1268+01	.1033+01	,8506+00	,7068+00

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

	DELTA-P TO S	SUPPLY ACCELER	RATION HEAD		DELTA-P DUE	TO LINE FRICT	ION AND CONFI	SURATION LOS
ELTA IME	ENGINE LINE NO 1	ENGINE LINE NO 2	FINE NO 3	ENGINE LINE NO 4	ENGINE LINE NO 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4
-100-	,00000000	,00000000	,000000000	.00000000	,00000000	.00000000	,00000000	,00000000
.20	41769110-01_	.76351536+01	,98341784=01.	00000000		_,67791624-05_	78310665±05.	_,00000000_
.40 60	,41769109-01	,76351536+01	,98341782=01	.00000000	,45958857704	+61012462-04	,70479599=04	.00000000
	,83538221-01	.15270308	,19668357	.00000000	.18383543+03	,24404985=03	,28191840=03	,00000000
,80	\$4299843	.99256998	1.2784432	.00000000	22519839902.	29896106+02_	.,34535003+02.	_,00000000
1,00	-,25061462-01-	45810915=01	,59005060=01	.00000000	,56966513=02	175625624=02	.87360246-02	,00000000
1+20	m,16707646-01-	.30540619-01	,39336719=01	.00000000	,53606410=02	171164935=02	,82207404-02	,00000000
L • 40		.0000000			,52290966=02.	69418623=02.	.80190120-02	00000000
L+60 L+80	16707643	,30540613	139336711	.00000000	.66180752=02	,87857944=02	·10149062=01	,00000000
-	,58476748	1.0689214	1.3767848	.00000000	.14890669901	,19768038-01	,22835390=01	.00000000
2:00	1.2363657	2,2600056	2.9109170	00000000	,48643671901	_464576673=01_	74596860 <u>=01</u>	_,00000000
2,20 2,40	1,2363655	2,2600053	2,9109165	.00000000	,12555061	,16667411	,19253648	.00000000
-	1.2363657	2,2600056	2,9109170	.00000000	,23825071	,31628860	,36536624	,00000000
2.60	1.2363655	.2,2600053	2,9109165	00000000	,38674399	_,51342013	_,59308614	_,00000000
2,80 3,00	1,2363657	2,2600055	2,9109168	.00000000	,57103042	,75806872	87569617	,00000000
	,83538232	1,5270310	1,9668359	.00000000	.75298991	,99962818	1,1547378	.00000000
3.20		.15270291	.19668336	00000000	84174157	1.1174500	1,2908417	,00000000
3.40 3.69	.00000000	.00000000	•00000000	.00000000	.85005499	1,1284865	1,3033906	.00000000
	,00000000	.00000000	.00000000	.00000000	.85005499	1,1284865	1.3035906	.00000000
3,80	,00000000	. 00000000	.00000000	.00000000	85005499	1,1284965	1.3035906	_,000000000

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

	DELTA-P TO	SUPPLY ACCELER	RATION HEAD		DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOS						
ELTA	ENGINE LINE NO 1	ENGINE LINE NO 2	FINE NO 3	ENGINE LINE NO 4	FINE NO \$	FINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4			
•00 •20	_	.14557779=01		_	•	.50801058-05	•				
,40		.16984076#01 .31541854#01			-	<u> </u>					
.60		.50952227=01			,47952643=03	,75199678+03	,99700893-03	,00000000			
.80	49705245-01	_,82494083+01_	13916092	00000000	.14743030=02	. 23120126 <u>=</u> 02	.30653019-02	00000000			
.20	,122801£9	.20380590	,34380931	.00000000		,85396580+02 ,25849836=01					
• 40	,14326806 24852625 <u>-0</u> 1	.23777706 .412 <u>47046-</u> 01:	.40111087 69580465 <u>=01</u>	• • • • • • •	¥	125549850±01 136559969±01					
.60	.20466868-01	,33968156=01	.57 ³ 01561=01	.00000000	.23039224401	,36130277=01	.47902078=01	,00000000			
.00		.82494070=01	_	.00000000	•	,43310160-01					
20	,18420180 ,13157269	.30571339	.36836708	000000000	.77827437¤Q1	<u> </u>	<u>.1933/833/441</u> .16181517	*000000000 *00000000			
40	,27776463	,46099638	,77766400	,00000000	,13174604	,20660508	.27392020	.00000000			
.60	,28215033	46827518	78994275		22834861		47477176	000000000_			
00	,15 ₀ 57766	.24990856 .72788867=02	,42157574	.00000000	.35813983	,50354023 ,56163745	.66760140 .74462758	,00000000			
.20	•	24263012=02			35957742	,56389189	74761655	.000000000			
•40 •60	,00000000	.00000000	.00000000	,00000000	,35993727	.56445621	174836475	.00000000			
, 80	,00000000	.00000000	.00000000	.00000000	.35993727	156445621	,74836475	.00000000 .00000000			

..3,80

4.00

12,061

-5,632

-17,044

-24,649

-29,863

=40,509 =41,360 =42,021

-39,402

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE_CASE_=_ORE	ITER 0404.	LOW PENMN	OXYGEN SUPPLY SYSTEM
-------------------	------------	-----------	----------------------

			ULLAGE PR	ESSURE REG	JIRED FOR	3 ENGINE	OPERATION					
PELTA	12:0 INCH MAIN LINE	13.0 INCH Main Line	14,0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 THCH	23.0 INCH
,00	#46,486	+46,486	-46,486	-46,486	-46,48 6	-46,486	-4614 96	#46,486	-46,486	=46,486	-46:486	+45,486
20	₹43·753	944,142	-44,452	•44,701	-44,906	-45:075	=45,217	745,337	-45,439	45,528	-45.604	-45,671
.40	43.750 -	944,140		#44,700		-45:074		945,336_	45,439	45,527_	-45.604	-45.670
160	#41.0 06	-41,790	-42,411	•42,912	-43,321	-43,661	+43,945	#44,185	-44.391	-44.567	-44.720	~44,85 4
- 180-	110,795	+15,910	-19,961	-23,225	-25.894	-28:104	-29,954	-31,520	-32,856	-34,005	-35.001	-35.870
1,00	=47.682_	47.+567	#47. ₁ 458.	-47,359	47., 271.	=47.,19.4.	<u>= 47,127</u>	z47.06B		=46.970.	-46,929	-46.894
1,20	#47.176	e47,132	-47,080	-47.028	+46,980	-461935	-46,895	=46,859	-46,826	#46,798	-46.773	-46,750
1,40-	#46,122	-46,231	-46,301	-46,348	-46,3RO	-46,402	-46,418	m46,430	-46,438	746,445	-46,450	-46,455
1.60	235.091	_=36,788	-38,114	239_171	<u>#40.029</u>	-40.734	-41,322	#41.817	-42,238	+42,599	-42.911	<u>-43.183</u>
1,80	w7:185	- 12,953	-17,483	-21.110	-24.060	-26,494	-28,526	=30,240	-31,698	-32,952	-34:037	-34,982
2:00.	37.780	25,229	15,421	7,600	1.256	•3,963	₹8,312	+11,976	-15,085	-17,759	-20:070	-22,082
2.20	43.072	28,920	18.079	9.570	2.755	-2.797	<u>=7,384</u>	<u>•11.221</u>	-14,449	-17,234	-19:612	-21,684
2,40	50.825	34,328	21,974	12,456	4,950	~1. 087	46,023	-10,117	+13,519	-16.440	-18:941	+21,100
2.60.	61.041	41,452	27,105	16,259	7,842	1.165	84,231	-8,661	*12,293	-15,408	+18.057	-20,332
2,80	73.718	50,294	33,473	20.978	11,430	3,959	-2,007	-6,855	-10,773	*14,127	-16,961	-19,379
3,00	59,996	36,527	20,232	8,505	4.198	-6.829	-11,997	- 16,105	-19,320	-22.065	-24:347	-26,267
3,20	16,909	-1,391	-13,310	=21,340	-26,911	-30.878	#33 ₁ 768	+35,916	-37,424	#38,697	-39.692	-40,480
3,40	12.029	-5.664	17,076	24.681	-29.895		<u>•36,191</u>	-38.118	-39.434	-40.541	-41:392	-42,053
3,60	12.045	-5,648	-17,060	-24,665	-29.879	•33,543	-36,175	#38,102	~39,418	+40,525	-41.376	-42.037

°33,527

-36,159

#38,086

IMSC-A991396

21,819

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

			ULLAGE PRI	ESSURE REG	JIRED FOR	3 ENGINE	OPERATION					
DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14,0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	20.522	20,501	20,484	20.470	20,459	20,450	20,442	20,436	20,430	20,425	20:421	20.417
120.	20.551	20,526	20,506	20,490	20,477	20,466	20,497	20,449	20,443	20,437	20,432	20,428
140	20.723	20,676	20,638	20.608	20.584	20,563	20,546	20,532	20.520	20,509	20:500	20,492
,60	20.959	20,885	20,818	20.768	20.728	20,695	20,647	20,643	20,623	20,606	20:592	20,579
	21.357	21,223	21,118	21,035	20,968	20,912	20,866	20,827	20,794	20.766	20.742	20,721
1.00	22.892	22,544	22,275	22.062	21.890	21.750	21,633	21.536	21.453	21,382	21 321	21,268
1.20	23,655	23,155	22,780	22,489	22,260	22.075	21,924	21,798	21,693	21,603	21:527	21,461
1.40	20.679	20,524	20,430	20,373	20,337	20,315	20,302	20,294	20.290	20,288	20.288	20,289
1.60	21,519	21.257	21,077	20,950	20.858	20,788	20,736	20,694	20,662	20,636	20,614	20,596
1,80	22,233	21,858	21,594	21,403	21,260	21.151	21,005	20,997	20,942	20,897	20:859	20,828
2,00	25,425	24,556	23,922	23,447	23,080	22,792	22,500	22,371	22,215	22.084	21.973	21,878
2,20	25.486	24,449	23,723	23,197	22,805	22,506	22,272	22,086	21,936	21,814	21,711	21,626
2.40	30.097	28,208	26,872	25,897	25,163	24,599	24,195	23,800	23,511	23,273	25:074	22,906
.2:60	33,416	30,625	28,694	27,312	26,294	25,525	24,932	24,465	24.091	23,787	23,537	23,329
2,80		30,669	28,428		25,748	24,926	24,309	23,836	23,467	23,175	22:941	22,750
3,00	52.434	29,118	26,932		24,405	23,661	23,116	22,711	22,404	22,168	21.984	21,639
3,20											21,969	
3,40	32,427	29,105	26,916		24,387	23,643	·	22,694	22,388	22,152		
3,60	32,412	29,091	26,902	25,414					22,378	22,143		
3.80	32,413	29.092	26,903	25.415	24,376	23,632	221099	22,685	22,379	22,144	21.962	21,818

23,633

24,377

22,686

23,090

22,380

22.145

25,416

26,904

29,093

32.414

4,00

45

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, LOW PENMIN

RANS, TIME	ULLVAP		MINULL OXID.	MINULL	TNKBGT OXID	TNKBOTFUEL	LINHEDOXID.	LINHED	ULLVOL	ULLVOL FUEL	TNKHEDOXID.		ULLWGT Oxid.	ULLWG FVEL
SEC	PSIA	PSIA	PSIA	PSIA	PSIA	PSIA	PSIA	PEIA	CU.FT.	CU.FT.	FT.	FT.	LAS	LBS
00	20.052	20.170	20,05	20,52	45,55	23,46	48,99	•.290	607.8	1784,5	51,78	96,19	209.6	149,
.20	20.052	_20,170_	20,05_	20,55_	45,55_	23,49	48,99_	= 12 <u>9</u> 0	607.8_	1784.7_	51,78_	96,19	209.6_	149,
.40	20,952	20,175	20,05	20,72	45,55	23.66	48,99	-,290	607,9	1785.1	51,78	96.18	209.7	151.
60	20.052	20,170	20,05	20.96	45,55	23,90	48,99	5 1240	608.0	1785,8	51,78	95,18	209,7	152.
.8n. 1 00	20,052	_20.170_	20.05	_21,36_	45.55_	24,29_	48,99	290	608.4	1787.1_	51,78_	96.18	202.8	156.
1,00	20,052	20.170	20.05	22,89	45,55	25,83	48.99	e 1290	609,0	1789,6	51,78	96,18	21ñ.i	168.
1,20 1,40	20.052	20.170	20,05	23,65	45,54	26,59	48,99	#+2 ⁹ 0	609,7	1794.0	51,78	95,17	210,3	175.
1.60	20.052	20,170	20,05_	20.68	45,54_	23,61_	48.99_	<u>= :290</u>	610,3_	1799.1	51.77_	96,16	31à.5_	151.
1,30	20.052	20.170	20.05	21,52	45,54	24,45	48.99	• • 290	610.9	1804.3	51,77	96,15	210.7	158,
2,00	20,052	20,170	20,05	22,23	45,54	25,17	48,99	. 29D	612.0	1809,9	51,77	96,14	211.1	165.
2.20	20.052	_20.17.j	37.78_	25,43_	63,.26_	28,36_	48,99_	<u> </u>	613,8_	1817.2	51.76_	95,13_	409.4	192
2,40	20.052	20,170	43,07	25,49	68,55	28,42	48,99	= 1290	616,8	1826,6	51,75	96,11	476.1	193.
2.60	20,052	20,173	.50,83	30.10	76.29	33.03	48,99	B (290	620,9	1838,9	51,73	96,09	574.1	233.
2,80	-	_20,175_		33,42_	86.50_				626,1	1855.1_	•	9\$1.06	71à.o	265.
3,00	20.052		73,72	34,00	99,16	36,93	48,99	• 1290	632,4	1874,3	51,68	96,03	890,5	274,
3,20	20.052	_	60.00	32.43	85.42	35,36	48,99	-1290	639,7	1894,6 1915.0	51,65	95,99 95,96	711.4 223.3	262
3,40		20,170		32.43	<u>45,46</u> 45,45	35,36_ 35,34	48 <u>,99</u> 48,99	#1290 #1290	<u>647,3</u> 655,0	1935,3	21,91. 51,58	^{92,,70}	225,9	<u>265</u> _ 267,
3,60		20,170	20,05	32,41 32,41	45,43	35,34	48,99	71270	662,8	1955,6	51,55	95,89	228,6	270.
	60 × U # E	E-U a 1 / 13			7/17/			* E ! V	44510	4-2-10		, - , - ,		

4,00

3,8Q_

4.00

20.052

20,052

20.052

20,052

20.052

SAMPLE CASE . ORBI	TER DADA LOW PENMI	N E OXYGEN SUPP	LY_SYSTEM_

MINIMUM REQUIRED ULLAGE PRESSURE FOR 3 ENGINE OPERATION PER MAIN FEED LINE

\$3.0 INCH 14.0 INCH 15.0 INCH 16.0 INCH 17.0 INCH 18.0 INCH 19.0 INCH 20.0 INCH 21.0 INCH 22.0 INCH 23.0 INCH DELTA 12.0 INCH MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE TIME .00 20,052 20.052 20:052 20.052 20,052 20.052 20.052 20.052 20.052 20,052 20.052 20.052 - 120 ... 20.052 20.052 20.052 20.052 20,052 20.052 20,052 20.052 20,052 20.052 20.052 20.052 .40 20.052 20.052 20.052 20.052 20.052 20.052 20.052 20.052 20.052 20.052 20.052 20.052 .60 20:052 20.052 20.052 20,052 20.052 20.052 20.052 20.052 20.052 20,052 20,052 20.052 --.80--20.052 20.052 20.052 20,052 20.052 20.052 20.052 20.092 20.052 20.052 20.052 20.052 1.00 20.052 20.052 20.052 20,052 20.052 20.052 20.052 20.052 20.052 20.052 20.052 _20.052_ 1.20 20:052 20,052 20,052 20.052 20,052 20.052 20.052 20.052 20.052 20.052 20.052 20.052 1.40... 20.052 20.052 20,052 20.052 20.052 20.052 20,052 20.052 20.052 20,052 20.052 20,052 1,60 20.052 20.052 20,052 20,052 20.052 20.052 20.052 20.052 20.052 20,052 20.052 20.052 1,80 20:052 20,052 20.052 20.052 20,052 20,052 20,052 20.052 20.052 20.052 20,052 20.052 2:00_ 37.780 20.052 20,052 20:052 20.052 20.052 20.052 20,052 20.052 20.052 20.052 25,229 2.20 20,052 20,052 20.052 20.052 20,052 20,052 20,092 20,052 20,052 20,052 43.072 28,923 2.40 20,052 20.052 20:052 20.052 20,052 20.092 20,052 50.825 34,328 21,974 20.052 20.052 2,60___ 20.052 20,052 20,052 20.052 20.052 61.041 41,452 27,105 20.052 20.052 20:052 20,052 2.80 20,052 20.052 20.052 20,052 73.718 50.294 33,473 20,978 20,052 20.052 20,022 20,052 3.00 20:052 20,052 59.996 36,527 20,232 20,052 20,052 20.052 20,052 20.052 20.052 20.052 3,20 20,052 20.052 20.052 20,052 20.052 20.052 20.052 20.052 20,052 20,052 20.052 20.052 3,40 20,052 20,052 20,052 20,092 20.052 20.052 20.052 20.052 20.052 20.052 20.052 20,052 3.60 20.052 20,052 20,032 20.052 20,052 20,052 20.052 20.052 20.052 20,052 20.052 20,052

20.052

20,052

20,052

20.052

20.052

20.052

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

		MINIMU4 R	EQUIRED ULI	LAGE PRESS	URE FOR 3	ENGINE OP	ERATION PE	R MAIN FEE	DEINE			
DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH Main Line									
.00	201722	20,501	20,484	20,470	20,459	20,450	20,442	20,436	20,430	20,425	20:421	20,417
-120	20.551	20,526	20,506	20,490	20.477	20,466	20,457	20,449	20,443	20,437	20,432	20,42
.40	20.723	20,676	20,638	20,608	20.584	20.563	20,546	20,532	20.520	20.509	20.500	20.492
160	20.959	20,880	20,818	20.768	20.728	20,695	20,697	20,643	20,623	20,606	20,592	20,579
+80	21.357	21,223	21,118	21,035	20.968	20,912	20,866	20,827	20,794	20.766	20.742	20,721
1.00	22.892_	22,544	22,275	22,062	21,890	2i.750	21,633	21,536	21,453	21.392	21:321	21,268
1,20	23.655	23,155	22,780	22,489			-	21,798	21,693	21,603	21.527	21,461
1,40	20.679	20,524	20,430	20.373	20,337	20.315	20,302	20,294	20,290	20,288	20.288	20,289
1.60	21.519	21,257	21,077	20,950	20.,858.	20.788	20,736	20,694	20.662	20,636	20:614	20.596
1,80	22.233	21,858	21,594	21,403	21,260	21,151	21,005	20,997	20.942	20,897	20.859	20,828
2,00	25,425	24,556	23,922	23,447	23,080	22,792	22,560	22,371	22,215	22,084	21,973	21,878
2.20	25.486	24,449	23,723	23,197	22.805	22.506	22,272	22.086	21.936	21,814	21.711	21.626
2.40	30·097	28,208	26,872	25.897	25,163	24,599	24,155	23,800	23,511	23,273	23:074	22,906
2,60	33,416	30,625	28,694	27,312	26,294	25,525	24,932	24,465	24,091	23,787	23.537	23,329
2,80	33,998	30,669	28,428	26.867	25,748	24,926	24,309	23,836	23,467	23,175	22:941	22,750
3,00	32.434	29,118	26,932	25,445		23,661	23,116	22,711	22,404	22,168	21:984	21,839
3,20	32,427	29,105	26,916	25,428	24,387	23,643	23,099	22,694	22,388	22,152	21.969	21,825
3,40	32.412	29.091	26,902		24.375		•	22,684	22,378	22,143	21,961	21,817
3,60		29,092	26,903	25,415				22,685	22,379	22,144	21.962	21,818
3,80		29.001	26.904	25 414	24 377		·	22.686	22.380	22.145		

23,633

24,377

25,416

26,904

29,093

23,090

22,686

22,380

22,145

Table 2-4 SOPSA OUTPUT DATA LISTING (CONT'D)

		TANK BOTT	OM PRESSUR	E VALUES FI	OR 3 ENGI	HE OPERATI	ON PER MAII	N FEED LIN	Ē			
PIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22,0 INCH MAIN L'INE	23.0 INCH
.00	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45,549	45:549	45,549
.40	45.549	45,549	45,549	45,549	45,549	45.549			45,549			
,60	45,548 45,548	45,548	<u>45,548</u> 45,548	45.548_ 45.548	<u>45.548</u> 45.548	451548 451548			45,548_ 45,548	45,5 <u>48</u> 45,548		
8 0		45,547	45,547						45,547			
1,00	45,546	45.546	45,546				·					45,546
1:40	45.545	45,545	45,545	45,545	45,545	45,545	45,545	45,545	45,545	45,545	45 545	45,545
1,60	45.543	45,543	45,543				. •		45,543	45,543		
1,80	45,542 45,540	45,542 45,540	45,542 45,540	45,542 45,540	<u>45,542</u> 45,540			45,542 45,540	45,542 45,540	45,542		
2.00	63.264	50,713	45,536	45,536	45,536				45,536	45,536		
2,20	68.549	54,397	45,529			•	,	45,529	45,529	45,529	45,529	45,529
2,40 2,60	76.294	59,796	47,442	45,521	45,521	45,521	. 45,521	45,521	45,521	45,521	45.521	45,521
2,80	86.498	66,910	52,563		45,510			45,510	45.510			
3,00	99.162 85.425	75,738 61,956	58,917 45,661	46,422 45,481		45,496 45,481			45,496 45,481	<u>45,496</u> 45,481		
3.20		45,465	45,465	45,465	45,465			45,465	45,465	45,465		,
3,40	45,449	45,449	45,449	45,449	45,449	45,449	45,449	45,449	45,449	45,449	45,449	45,449
3,60 3,80	45.432	45,432	45,432	45,432	45,432	45,432	45,432	45,432	45,432	45,432	45,432	
4,00	45,416	45,416	45,416	45,416	45,416	45,416	45,416	45,416	45,416	45,416	45,416	45,416

35,341

4.00

29,831

28,343

27.303

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A. LOW PENMY = HYDROGEN SUPPLY SYSTEM TANK BOTTOM PRESSURE VALUES FOR 3 ENGINE OPERATION PER MAIN FEED LINE DELTA 12.0 INCH \$3.0 INCH 14.0 INCH 15.0 INCH 16.0 INCH 17.0 INCH 18.0 INCH 19.0 INCH 20.0 INCH 21.0 INCH 22.0 INCH 23.0 INCH MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE TIME .00 23:357 23,372 23,366 23,458 23,437 23,420 23.407 23.395 23,386 23,378 23,362 23.354 -20 23.369 23,364 23,487 23,442 23,426 23,413 23,403 23,393 23,386 23,379 23,374 23,462 .40 _23.575_ 23.544_ 23.520 .23.500 23,433_ 23.468 23.456 23,446 23,436 23,429 23.659 23,612 ,60 23:528 23,754 23.664 23,603 23,580 23,560 23,543 23.515 23.895 23.816 23,705 23,631 -- 80 --23,764 23,731 23:678 23,657 24,293 24.159 24.054 23.971 23.904 23,848 23,802 23.702 1:00 24,509 24.472 24.389 .24 .318... 24.257 24.204 25.828... _25.,485_ 25,211 24.998 _24.826_ 24,686 1:20 24.463 25,195 24,859 24,734 24.629 24,539 24,397 26.591 26,091 25,715 25,425 25,011 1 , 40 - ----23:224 23,366 23.272 23,250 23,237 23,229 23,226 23,224 23,225 23,615 23,460 23.308 1,60 23,549 24.012 23.885 23.793 23.724 23.671_ 23,630 23.597 23.571 23,532 24.192 24.454 1.80 23:794 24,793 24,529 24.338 24.195 24.086 24,000 23,932 23,877 23,832 23,763 25,168 2,00 ... 24.908 24,813 25,495 25.306 25.149 28.360 27,495 26,857 26.381 26.015 25.726 25.018 2.20 25.739 25.020 24.871 24.748 24,646 24,560 25.440 25.206 28 420 27,383 _26 .657_ 26.131 2,40 26,733 26,444 26:007 25,839 29,806 28.097 27.532 27,088 26,206 33.030 31.141 28,830 2,60 27,397 27.024 26,720 26.470 26,262 30,244 29,227 28,458 27,864 36.349 33,557 31,626 2.80 36.929_ 31,359 29.798 28.680 27.858 27,240 26,767 26,399 26,107 25.872 25,681 33,601. 3.00 29,863 28.376 27,336 26,591 26:047 25,641 25,334 25.098 24.915 24.770 35.365 32,049 3,20 24.899 29,846 28.357 27.317 26.572 26,028 25,623 25,317 25.082 24,754 35.357 32,035 3,40 24,889 29,831 28,343 27.303 26,559 26,016 25,612 25,306 25,072 24,745 35,341 32.019 3,60 24.889 24,745 35,341 32,019 29,831 28,343 27,303 26.559 26,016 25,612 25,306 25,072 3.80

26,559

26,016

25,612

25,306

25.072

24,745

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

		RECOMPUTE	D ENGINE P	RESSURES F	OR 3 ENGI	NE OPERATI	ON PER MAI	N FEED LINE				
DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH	19.0 INCH MAIN LINE	20.0 INCH	21.0 INCH MAIN LINE	22.0 INCH	23.0 INCH
.00	94.539	94,539	94,539	94.539	94,539	94,539	94,539	94,539	94,539	94,539	94:539	
140	91.805	92,195	92,504	92,754	92,958	93,127	621508	93,389	93,491	93,580	93.656	93,723
٠	91.802	92,192_	92,502	92.752	92,957	93,126	93,266	93,388	93,491	93,579	93,656	93,722
160	89.059	89,842	90,463	90,964	91,373	91,713	91,997	92,237	92,443	92.619	92:772	92.966
18D.	58,847	63,962	68,013	71,277	73,946	76,156	78,037	79,572	80,908	82.057	83,053	83,922
1.00	95.734	95,619	95,510	95,411	95,323	95,246	95,179	95,120	95,067	95,022	94,982	94,946
1,20	95.228	95,184	95,132	95,081	95,032	94,987	941947	94,911	94,878	94,850	94.825	94,802
1:40	94.174	94,283	94,353	94.400	94,432	94,454	94,471	94,482	94,491	94,497	94.503	94,507
1.60	83.143	84,840	86,166	87,224	88,081	88,787	89,374	89,870	90,290	90,651	90:964	91,235
1,80	55.238	61,005	65,535	69,162	72,112	74.546	76 578	78,292	79.750	81,004	82:089	83,035
21.00.	28,000	28,000	32,631	40,453	46,796	52,016	50,305	60,028	63,137	65,811	68.122	70.134
2,20	28,000	28,000	29,973	38,482	45,298	50,849	55,436	59,274	62,501	65,276	67,664	69,736
2,40	28.000	20,000	28,000	35,596	43,102	49,139	34,075	58,169	61,571	64,492	66,993	69,152
.21.60	28.000	28,000	28,000	31,793	40.211	46,888	52,243	56,713	60.345	63,460	66.110	68,384
2,80	28.000	28,000	28,000	28,000	36,622	44,093	50,060	54,907	58,825	62,179	65.013	67,431
3.00	28,000	28,000	28,000	39,547	48,250			64,157	67,372	70.117	72.399	74,319
3,20	31.144	49,443	61,362	69,392	74,963	78,930	81,820	83,968	85,476	86.749	87.744	88,532
3,40	36,023	53,716	65,128	72,733	77,947	81,611	84,243	86,170	87,486	88,594	89,444	90,105
3,60	36.007	53,700	65,112	72,717	77,931	81,595	<u>94</u> ,227	86,154	87.470	88.577	89,428	90,089
J100	35.991	53,684	65,096	72.701	77.915	81.579	84,211	86,138	87.454	88,561	89,412	90,073

3,60

3.80 ...

4.00

23.00C

23,000

23.000

23,000.

23,000

23,000

23.000

23,000

23,000

23.000

23,000

23.000

23.000.

23,000

23.000

23,000

23,000

23,000

23.000

23:000

23:000

23.000

23.000

23.000

Table 2-4
SOPSA CUTPUT DATA LISTING (CONT'D)

SAMPLE CASE = ORBITER 040A LOW PENMN = HYDROGEN SUPPLY SYSTEM RECOMPLITED ENGINE PRESSURES FOR 3 ENGINE OPERATION PER MAIN FEED LINE DELTA 12.0 INCH \$3.0 INCH 14.0 INCH 15.0 INCH 16.0 INCH 17.0 INCH 18.0 INCH 19.0 INCH 20.0 INCH 21.0 INCH 22.0 INCH 23.0 INCH MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE TIME .00 23:000 23,000 23.000 23,000 23.000 23.000 23.000 23.000 23.000 23.000 23.000 23.000 --120-23:000 23,000 23.000 23,000 23.000 23.000 23.000 23.000 23.000 23.000 23,000 23.000 .40 23:000 23.000 .23+000. 23.000 .23 ..000. 23.000 23.000 _23.000 23.000 23,000 .23..000 23.000 .60 23:000 23.000 23,000 23,000 23,000 23,000 23,000 23,000 23,000 23,000 23,000 23.000 -----80--23.000 23,000 23,000 23.000 23.000 23.000 23.000 23,000 23,000 23,000 23.000 23,000 1.00 23,000 23,000 23,000 23,000 23,000 23..000 23,000 23.000 23,000 23.000-.23.000 23,000 1,20 23:000 23,000 23.000 23,000 23,000 23,000 23.000 23,000 23.000 23.000 23,000 23,000 1.40 23,000 23.000 23.000 23.000 23.000 23,000 23,000 23,000 23.000 23,000 23.000 23,000 1.60 23,000 .23.000. 23.000 23.000 23,000 23.000 23.000 23,000 23.000 23.000. .23..000.<u>.</u> .23.00g. 1:80 23,000 23.000 23,000 23,000 23.000 23,000 23,000 23,000 23,000 23,000 23.000 23,000 2.00 23,000 23,000 23:000 23.000 23.000 23,000 23.000 23.000 23,000 23,000 23,000 23,000 2.20 23,000 23.000 .23.000. 23.000. 23,000 23.000 .23,000. 23.000_ .23,000 _23,000. 23,000 .23.000. 2.40 23.000 23,000 23,000 23,000 23.000 23,000 23,000. 23.000 23,000 23,000 53,000 23,000 2.60 23,000 23.000 23.000 23,000 23.000 23,000 23,000 23.000 23.000 23,000 23,000 23.000 2.60 23,000. 23,000 23.000 23.000 23.000 23.000 .23.000. 23,000. 23.000 23,000 _23.000... _23,000. 3,00 23,000 23,000 23.000 23,000 23.000 23,000 23.000 23,000 23.000 23.000 23,000 23,000 3,20 23,000 23,000 23,000 23,000 23,000 23:000 23,000 23,000 23.000 23,000 23.000 23.000

23.000

23,000

23.000

23.000_

23,000

23,000

23,000

23,000

23,000

23.000

23,000

Table 2-4
SOPSA OUTOUT DATA LISTING (CONT'D)

	MAIN FEEDLINE	EN	GINE FEEDL	INE WEIGHT		TOTAL ENGINE	MAIN	ENGINE FEEDLINE	MAIN FEEDLINE	TOTAL
PROPELLANT	DIAMETER (INCHES)	_1NE NO 1	LINE NO 2	LINE NO3	LINE NO 4	FEEDLINE WEIGHT	PEEDLINE WEIGHT	INSULATION	INSULATION WEIGHT	FEED SYSTEM WEIGHT
OXYGEN	12,900	282,46	288,95	293,08	.00000	864,49	1331,6	15,585	72,077	2283,7
OXYGEN	13,000	282,46	288,95	293,08	00000_	864,49	1560.4	15,585	78,322	2524.8
OXYGEN	14.000	282,46	288,95	293,08	.00000	864,49	1823,6	15,585	84,631	2/93,3
OXYGEN	15,000	282,46	288,95	293,08	.00000	864,49	2120.0	15,585	91,002	3091,0
OXYGEN	16.000	282,46	288,95	293.08	00000	864.49	2445,4	15,585	97,436	3423.0
OXYGEN	17:000	282,46	288,95	293.08	.00000	864,49	2813,1	15,585	103,93	3797.1
OXYGEN	18.000	282.46	288,95	293,08	.00000	864.49	3210,6	15,585	110,49	4207.2
OXYGEN	19.000	282,46	288,95	293.08	00000	864.49	365/,7	15,585	117,12	4654.9
OXYGEN	20.000	282,46	288,95	293,08	.00000	864,49	4137,9	15,585	123,60	5147.8
OXYGEN	21.000	282,46	288,95	293.08	.00000	864,49	4659.0	15,585	130.55	5669.7
OXYGEN	22.000	_282.46	288,95	293,08_	00000	864.49	5222.7	15,585	137,36	6240.2
OXYGEN	23,000	282,46	288,95	293.08	100000	864.49	5833,7	15,585	144,24	6855.0
HYDROGEN	12,000	291,08	252,21	331,46	100000	874,75	711,31	.00000	•00000	1586,1
HYDROGEN	13,000	291.08	252.21	331,46	.00000	874,75	871.90	,00000	.00000	1746.7
HYDROGEN	14:000	291.08	252,21	331.46	00000	874,75	1057.0	00000	00000	1931.8_
HYDROGEN	15,000	291.08	252,21	331.46	00000	874,75	1268,5	00000	.00000	2143,2
HYDROGEN	16,000	291,08	252,21	331.46	00000	874.75	1500.1	,00000	.00000	2382.9
HYDROGEN	17:000	291.08	252,21	331,46	00000	874,75	177/19	00000	00000	2052,6
HYDROGEN .	18,000	291.08	252,21	331,46	00000	874.75	2079.8	,00000	.00000	2954,6
HYDROGEN	19,000	291.08	252.21	331.46	00000	874+75	2416,3	.00000	.00000	3297.1
HYDROGEN	20.000	291.08	252,21	331.46	00009	874,75	2793 0	00000	00000	3664.8
HYDROGEN	21,000	291,08	252,21	331,46	00000	874.75	3201,3	.00000	.00000	4079.0
HYDROGEN	22,000	291.08	252,21	331,46	,00000	874.75	3063,7	,00000	.00000	4538.4
HYDROGEN	23.000	291.08	252,21	331,46	00000	874,75	4175,3	.00000	00000	5050.0

END OF CASE 1

SC-A991396

Table 2-4 SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN INPUT JATA FOR START TRANSIENT PROBLEM CONSIDERED IN THIS ANALYSIS, THE NUMBER OF LINE SIZES TO BE CONSIDERED IS THE PROBLEM CONSIDERS BOTH OXIDIZER AND FUEL FEED SYSTEMS THE NUMBER OF ENGINES FOR THE VEHICLE IS 3 THE NUMBER OF ENGINES FOR EACH FEED SYSTEM IS THE MOMINAL OXIDIZER FLOW RATE IS 894,00 LBS/SEC -THE NOMINAL FUEL FLOW RATE IS .. 149,00 LBS/SEC THE VEHICLE LUADED WEIGHT IS 5503250,00 LBS THE NOMINAL THRUST FOR EACH ENGINE IS 470000,00 LBS THE BULK OXID, ENGINE INLET TEMPERATURE IS 162,90 DEG.R. THE BULK FUEL ENGINE INLET TEMPERATURE IS 37,00 DEG.R THE COMPONENT PRESSURE TOLERANCE IS 3.00 PSI -THE OXID - HEAD HEIGHT IN THE TANK IS - 51.784 FT THE OXID. HEAD HEIGHT IN THEFEED LINE IS 99,500 FT THE FUEL HEAD HEIGHT IN THE TANK IS 96.186 FT THE FUEL HEAD HEIGHT IN THE FEED LINE IS . =9.500FT..... THE INITIAL ULLAGE VOLUME IN THE OXIDIZER TANK IS 608.CU.FT THE INITIAL ULLIAGE VOLUME IN THE FUEL TANK IS 1784, CU,FT THE INITIAL OXIDIZER COADING IS 1743858 LBS THE INITIAL FUEL LOADING IS 290643, LBS THE EXTERNAL SURFACE AREA OF THE DROP TANK IS 13653.1 SQ. FT. THE EXTERNAL SURFACE AREA OF THE LOX/LH2 BULKHEAD IS 1160.2.SQ._FL THE TOTAL SURFACE AREA IS THEREFORE 14813,4 SQ, FT, THE OXYGEN FEEDLINE DESIGN PRESSURE IS .00000000 THE HYDROGEN FEEDLINE DESIGN PRESSURE IS .00000000

SOPSA OUTPUT DATA LISTING (CONT'D)

THE TANK GEOMETRY INPUT VALUES ARE AS FOLLOWS . .

L1= 120,000 L2# 549,000 L3= 551,000 L4=1691,000 R1= 120,000 R2# 120,000 R3# 128,000 R4# 181,000 R5# 128,000

	OXIDIZER		FEED LINE DATA	FUEL LINES	
DIAMETER INCHES	LENGTH FEET	K-FACTOR	DIAMETER INCHES	LENGTH FEET	KEFACTOR
12,00	6.80	,4143	12,00	7.14	4073
12,00	12.43	5499	12,00	11.85	6388
12,00	16.01	6353	12.00	19,99	8469
12,00	143.00	3,0925	12.00	39.00	1,421
13,00	143.00	2,9399	13.00	39.00	1,3822
14.00	143.00_	2,8095	14,00	39.00	1.349
15,00	143.00	2,6970	15,00	39,00	1,321
16,00	143.00	2,5991	16,00	39.00	1,297
17.00	143.00	2,5133	17,00	39.00	112/69
18.00	143,00	2,4375	18,00	39.00	1,259
19,00	143.00	2,3702	19.00	39.00	1,243
20.00	143.00	2,3601	20.00	39.00	1,230
21,00	143,00	2,3063	21.00	39.00	1,218
22,00	143.00	2,2579	22,00	39,00	1,208
23,00	143,00	2,2142	23.00	39.00	1,199

<u> </u>	COMPONENT DESCRIPTORS FOR MAIN OXYGEN FEEDLINE									
COMPONENT	TYPE	MATLI	INSUL	SPEC1	SPECZ	SPEC				
ī	1	0	٥	.0000	.0000	.0000				
2	3	2	5	5.000	20,00	,7500_				
3	20	0	0	.0000	.0000	0000				
4	3	2	5	9,160	13,33	.7500				
	30	O <u> </u>	0	0000	0000	0000_				
6 .	3	2 ·	5	4,160	8,330	.7500				
7	2	2	. 5	7,000	.0000	.7500				
8	22	0	0	0000	0000	0000_				
9	2	2	5	72.00	.0000	.7500				
10	22	0	0	.0000	.0000	.0000				
11	2	2	5	4,000		7500				
12	5	2	5	4,100	1,750	7500				
13	3	2 .	5	1,380	1,750	7500				
14	2	2	5	4.000	0000	7500_				
15	15	0	0	,0000	.0000	0000				
16	20	Ŏ	Ö	0000	.0000	0000				
17	3	_ Ž	5	1,000	1,270	7500				
18	20	0	0	.0000	.0000	.0000				
19	2	ž	5	1,500	.0000	.7500				
20	16	ā	0	0000	0000	3000				
21	. 3	2	5	4,000	7,650	7500				
22	15	ō	0	.0000	.0000	0000				
23	20	ň	ŏ	.0000	0000	0000				

Talle 2-4

			1001	J ,			
					(CONT'D)		
24	2	2	5	7 , oou	0000	7500	
25	20	0	Q	.0000	. 0000	,0000	
26	8	2	5	1,000	1,500	.7500	
(COMPONENT	DESC	RIPTORS	FOR ENGIN	E OXYGEN FE	EDLINE NUMBER	1
OMPONENT	TYPE_	MAT	_INSUL	SPEC1	SPEC2	SPEC3_	
ï	20	0	0	,0000		.0000	
2					1,500	,7500	
3	20 15	0	0	.0000	.0000	.0000	
					.0000		
(COMPONENT	DESC	RIPTORS	FOR ENGIN	Z: OXYGEN FE	EÓLINE NUMBER	2
OMPONENT	TYPE	.MAT <u>L</u> L.	_INSUL	SPEC1	5PEC2	SPEC3	
i	20	0	0	.0000	.0000	.0000	
 -				_5,500	1,750	7500	
3	3 20	2	5	3,930	2,500 .0000	.7500	
•			0	ຸດປູດຸດ		.0000	
				•	-	EDLINE NUMBER	3
OMPONENT	TYPE	MATU	INSUL	SFEC1	SPEC2	SPEC3	
<u> </u>	20	0		0000	0000	0000	
2	3	2	5	4,710	2,000 2,860	.7500 .7500	
3	3	2	5	1,500	2,860 ,0000	•7500	
4	2	2	5	3,000		,7500	
5	3	2	5	3,800	1,500	.7500	
. 5 . 7	15	0.	0	, Մըրը Մորը	.0000		
					HYDROGEN F	0000 EEDLINE	
OMPONENT	TYPE	MATE	INSUL	SPEC1	SPEC2	SPECS	
	· · ·	-				· -	
-			•	0660		-000	
ī		. 0	o•		0000		-
2	2	7	0	1,000	.0000	.0000	
	2 20		0	1,000	.0000	.0000	
2 3 4	2	7	0	1,000	.0000 .0000 12.00	.0000 .0000 	
2	20 3	7 0 7	0 0 0	1,000 .0000 9,440 .0000	.0000 .0000 12.00 .0000	.0000	
2 3 ——4——— 5	20 20 3 20 3 20	7 0 7 0 7	0 0 0 0	1,000 .0000 9,440	.0000 .0000 12.00	.0000 .0000 .0000	
2 3 4 5 6 7	20 20 3 20 3 20	7 0 7 0 7 0	0 0 0 0 0 0 0 0 0	1,000 ,0000 9,440 ,0000 9,440 ,0000	.0000 .0000 12.00 .0000 12.00 .0000	.0000 .0000 .0000 .0000 .0000	
2 3 4 5 6 7 8	2 20 3 20 3 20 15	7 0 7 0 7 0 7	0 0 0 0 0 0	1,000 .0000 9,440 .0000 9,440 .0000 .0000 2,750	.0000 .0000 12.00 .0000 12.00 .0000	.0000 .0000 .0000 .0000 .0000	
2 3 4 5 6 7 8 9	2 20 3 20 3 20 15 3	7 0 7 0 7 0 7	0 0 0	1,000 ,0000 9,440 ,0000 9,440 ,0000 2,750	.0000 .0000 12.00 .0000 12.00 .0000 .0000	.0000 .0000 .0000 .0000 .0000 .0000	
2 3 4 5 6 7 8 9	2 20 3 20 3 20 15 3	7 0 7 0 7 0 7	0 0 0 0 0 0 0	1,000 .0000 9,440 .0000 9,440 .0000 .0000 2,750 .0000 .9200	.0000 .0000 12.00 .0000 12.00 .0000 .0000 1.750	.0000 .0000 .0000 .0000 .0000 .0000	
2 3 4 5 6 7 8 9 10	2 20 3 20 3 20 15 3 16	7 0 7 0 7 0 7 0 7	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1,000 .0000 9,440 .0000 9,440 .0000 .0000 2,750 .9200 .0000	.0000 .0000 12.00 .0000 12.00 .0000 1.750 .0000	.0000 .0000 .0000 .0000 .0000 .0000 .0000	
2 3 4 5 6 7 7 8 9	2 20 3 20 3 20 15 3	7 0 7 0 7 0 7	0 0 0 0 0 0 0	1,000 .0000 9,440 .0000 9,440 .0000 .0000 2,750 .0000 .9200	.0000 .0000 12.00 .0000 12.00 .0000 .0000 1.750	.0000 .0000 .0000 .0000 .0000 .0000	

COMPONENT DESCRIPTORS FOR ENGINE HYDROGEN FREDLINE NUMBER 1

COMPONENT TYPE MATE INSUL

SPEC1

SPEC2

SPEC3

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

	8	7	0	1,000	1,350	0000
2	20	0	0	.0000	.0000	.0000
~ ~	3	7	0	3,140	1.500	.0000
	20	0	Ö	0000	0000	0000
5	15	Q	Õ	0000	.0000	.0000
C	OMPONEN	IL DESC	RIPIORS	FOR ENGIN	E. HYDROGEN_E	FEEDLINE NUMBER
COMPONENT	TYPE	MATLI	INSUL	SPEC1	SPEC2	SPEC3
1	3	7	0	2,350	1,500	,0000
ŝ	4	7	0	7,500	1.500	.0000
· • • • • • • • • • • • • • • • • • • •	_ 20	0	0	0000	0000	
4 .	15	0	0	.0000	.0000	.0000
Cı	OMPONEY	T DESC	RIPTORS	FOR ENGIN	E HYDROGEN F	EEEDLINE NUMBER
COMPONENT	TYPE	MATU	INSUL	SPEC1	SPEC2	SPEC3
	20	0	0	.0000	.0000	0000
5	3	7	0	2,350	1.500	.0000
•	Š	7	Ŏ.	9,150		0000
<u> </u>		_ :				,0000
	3	,	U	3.470	1./20	4 U V V V
_	20 20	0	0	5,490 .0000	1,750 .0000	.0000

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

THE TIME DEPENDENT	PERFORMANCE	CHARACTERISTIC	INPUT	VALUES	ARE	AS FOLLOWS .

	- TIME	NP\$P0	N2SPH	WD.TFRO	WDTERH	FIFRAC	PENMNO	<u> </u>	PPDGOT	PPDGHT	TDGOT	TDGHT
	.00	8,00	2,00	.000	.000	.000	60,00	30,00	,00	,00	190,00	60,00
	.20	8,00	2.00	.000	.006	.000	60,00	30,00	.00	,00	190,00	60.00
		8,00	2,00	,005		005	60.00	30,00	00	00	190,00	60.00_
	60	8.00	2,00	.010	.026	.010	60.00	33,00	,00	.00	190,00	60,00
	80	8.00	2,00	.020	.047	.020	60,00	30,00	00	,00	190,00	60.00
	1,00	8 , 00	2,00		081	085	60,00	30,00	00	00	190,00	60.00_
	1,20	8.00	2,00	,082	.165	.082	60.00	30,00	.00	• 00	190,00	60,00
	1,40	8.00	2.00	.080	, 263	.080	60,00	30,00	,00	.00	190, <u></u> 00	60.00
	1,60	8.00	2,00	080	,246	080	60,00	30,00	00	00	190,00	60.00
	1,80	8.00	2.00	.100	,260	.100	60,00	30.00	,00	,00	190,00	60.00
,	2.00	8.00	2,00	+170	294	.170	60.00	30,00	.00	,00	190.00	60,00
	- 2,20	8,00	2,00	,318	420	318	60,00	33,00	00	,00	190.00	60.00.
	2,40	8,00	2.00	,466	,510	.466	60.00	30,00	.00	,00	190,00	60.00
	2,60	8:00	2,00	.614	,700	.614	60.00	30,00	.00	,00	190,00	60.00
	-2.80	8.00-	2,00	762	,893	,762	60.00	30,00	00	,00	190.00	60.00_
	3,00	8,00	2,00	910	996	.910	60.00	30,00	• 00	,00	190,00	60,00
	3,20	8,00	2,00	1.010	,999	1.010	60,00	30,00	.00	,00	190,00	60,00
	3,40		2,00	1,020	1.000	1.020	60,00	30,00	00	,00	190.00	60.00_
	3,60	8 00	2.00	1.020	1,000	1.020	60.00	30,00	.00	,00	190,00	60.00
	3,80	8,00	2,00	1,020	1,000	1.020	60,00	30,00	,00	00	190,ñO	60.00
	4.00	8,00	2.00	1,020	1.000	1.020	6DDO	30,00	00	00	190.00	60.00

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMBLE	CASE -	_DRBITER	DADA.	HIGH	DENMN	
BANPLE_	LASE	LUNDI IEK	UQUA	חענה	LEMMA.	

						•					
TANS	WDDQT		VEHICLE WEIGHT	T/W RATIO	DELPHD 0x1D:	DELPHO FUEL	PROP-0 INCR	PROP-E INCR	PROP-TOT CUM	PENGOXID	PENG FÜEL
,00	,000	4,470	5503249,75	1.000	74.49	2,65	,000	,268	,268	60,00	3ã.00
20	22,350	5,215	5503247,56	1,000	74,49	2,65	1,341	,849	2,458	60,00	30.00
.40	22.350	9,685_	_5503241.81_	_1.000	74,49	2,65	4,023	1.743	8,225	_60,00_	
.60	44,700	15,645	5503230,56	1,000	74,49	2,65	B 1046	3,263	19,534	60,00	35.00
,80	290,550	25,330	5503196,69	1.000	74,49	2,65	28,161	5,722	53,416	60,00	30.00
1.00	-13,410	62,580_	_5503140.94	_1,000	74,48	2,65	44,749	10.996_	109,202	_60,00_	36.60_
1.20	#8,940	73,010	5503078,37	1.000	74,48	2,65	43,448	19,132	171,782	60,00	3ñ.00
1,40	,000	P12,665	5503012.75	1,000	74,48	2,65	42,912	22,752	237,446	60,00	30.00
1.60	89.400	10.430	5502941.87	_1.000_	74,48	2,65	48,276	22,618	308,341	60.00	30.00
1,80	312,900	25,330	5502844.75	1.000	74,48	2,64	72,414	24,764	405,518	60.00	30,00
2,00	661,560	93,870	5502682,00	1.000	74,47	2,64	130,842	31,916	568,316	60,00	30.00
2,20	661,560	67,050	5502430.19	1.000	74,47	2,64	210,269	41,571	820,156	60,00	<u>36,00</u>
2,40	661,560	141,550	5502086,50	1.000	74,46	2,64	288,656	54,087	1163,899	60,00	30.00
2.60	. 661,560	143,785	5501646,25	1.000	74,45	2,64	309,043	71,207	1604,149	60,00	30.00
2,80	661,560	76,735	5501113,44	1,000	74,43	2,64	448,430	84,438	2137,018	60,00	30,00
3.00	447,000	2,235	5500509.37	1.000	74,42	2,64	514,944	69,176	2741.136	60,00	3ñ.00
3.20	44,700	,745	5499875,62	1,000	74,40	2,64	544,446	89,355	3374,939	60,00	30.00
3,40	.000	000	-		74,39	2,64	547,128	89.400	4011,467	60.00	30.00
3.60	.000	,000	5498602.62	1.000	74,37	2,64	547,128	89,400	4647,995	60.00	30.00
3,80	,000	,000	5497966,12	1,000	74,35	2,64	547,128	89,400	5284,523	60,00	30,00
4.00											

છ

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 0404, HIGH PENMN - CXYGEN SUPPLY SYSTEM

DELTA-P TO SUPPLY ACCELERATION HEAD

DELTA TIME	12:0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
,00	•000	,000	,000	.000	.000	.000	,000	,000	.000	.000	:000	,000
	2,635	2,245	1,936	1,686	1.482	1,313	1,171	1,051	,949	,860	.784	,717
. 140	2.635_	2,245	1,936.	1,686	1,482	1,313	1,171	1,051	.949	.860		717
160	5,270	4,491	3,872	3,373	2,965	2.626	21342	2,102	1,897	1,721	1.568	1,435
,80	34.257	29,189	25,168	21,924	19.269	17:069	15,225	13,665	12,332	11.186	10:192	9,325
1.00	1.581	=1 ₊ 347	1,162			,788		s,63 <u>1</u>	569_	-,516	- 470	<u> </u>
1,20	a1.054	-, 898	a:774	-,675	٠,593	-,525	-1468	-,420	-,379	-,344	₩:314	-,287
1,40	•000	,000	.000	.000	.000	.000	1000	.000	.000	.000	:000	.000
1.60	10.541_	8,981	7,744	6.,7.66.	5,929	5.252	4,635	4,205	3,795	3,442	3.136	2,869
1,80	36,892	31,435	27,104	23,611	20,752	18,382	16,396	14,716	13,281	12.046	10.976	10,042
2,00	78,000	66,462	57,306	49,920	43,875	38,865	34,667	31,114	28,080	25,469	23.207	21,233
2,20	7.8 , 000_	66,462	57,306	49.920	43,875	38,865	34,667	31,114	28,080	25,469	23.207	21,233
2,40	78.000	66,462	57,306	49,920	43,875	38,865	34,667	31,114	28,080	25,469	23:207	21,233
2,60	78,000	66,462	57,306	49,920	43,875	38,865	34,667	31,114	28,080	25,469	23.207	21,233
2,60	78.000	66,462	37.306	49.920	43,875	38.865	24,667	31,114	28,080	25,469	23:207	21,233
3,00	52.703	44,907	38,720	33,730	29,645	26,260	23,424	21,023	18,973	17,209	15.680	14,346
3.20	5,270	4,491	3,872	3,373	2,965	2.626	2,342	2,102	1,897	1,721	1,568	1,435
3,49			.000	000		000			000			.000
3,60	.200	.000	,000		•		-	,000	,000	,000		,000
3.80 4.00	000	,000	,000	,000			000	,000	,000	000	.000	,000

4,00

IMSC-A991396

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

_SAMPLE CASE	- ABBITED	0404.	HIGH OFNIAN	- HYDROGEN	SHPPI V SVSTE	м.
JAMPLE.LADE_!	-UKDIIEK	. UTUA.	HIUM PENMN	S. HIDNUYEN	SUPPLY STOLE	. m

DELTARP TO SUPPLY ACCELERATION HEAD

DELTA TIME	12.0 INCH	13.0 INCH MAIN LINE	14.0 INCH MAIN LINE	15.0 INCH	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH	21.0 INCH Main Line	22,0 INCH	23,0 MAIN	INCH
,00	.144	1122:	,106	.092	.081	.072	1064	,057	, 052	.047	:043		.039
20	.168	1143.	,123	.107	,094	,084	1075	,067	,060	, 055	.050		.046
.40	311_	,265				155	138	,124	112	102			085_
,60	.503	.429	. ,370	,322	.283	.251	,224	.201	,181	.164	1150		,137
80.	.814	1694	,598	,521	,458	,406	1392	, 325	,293	,266	.242		,222
1.00	2.012	1,715	1,478	1.288	1,132	1.003	1894	803	.724	657	. 599		.548
1,20	2,348	2,000	1,725	1,503	1,321	1.170	11043	,936	,845	.767	.698		,639
1,40	407	*,347	F,299	•.261	₩,229	-,203	0,171	₹,162	-,147	-,133	121	•	.111
1,60	. 335	1286	1246	.215	.189	167	,149	,134	,121	,110	.100		,091
1,80	.814	,694	,598	.521	.458	.406	1392	325	,293	,266	.242		.222
2.00	3.018	2,572	2,218	1,932	1,698	1.504	1,342	1,204	1.087	,986	.898		.822
2,20	2,156	1.837	1,584	1.380	1,213	1.074	,958	,860	.776	.704	641		587.
2,40	4,552	3,878	3,344	2,913	2,560	2,268	2,023	1,816	1,639	1,486	1,354	1	.239
2,60	4,623	3,940	3,397	2,959	2,601	2.304	2,055	1,844	1.664	1.510	1.376	1	.259
2,80	2.467	2,102	1,813	1.579	1.388	1,229	11097	,984	.888	,806	734		,672
3,00	.072	1061	.053		<u>:</u>	, 036	,032	.029	.026	.023	:021		.020
3.20	.024	.020	,018	.015	.013	,012	1011	,010	,009	.008	.007		,007
3,40	.000	.000	000	000	.000	.000	1000	.000	.000	.000	:000		000
3,60	.000	,000	,000			.000	,000	,000	,000	.000	:000		.000
3,80	.000	.000	,000	.000	.000	.000	,000	.000	.000	.000	.000		.000

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 0404, HIGH PENMN ... - OXYGEN SUPPLY SYSTEM

DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE										
: 100	.0000	.0000	.0000	•0000	.0000	,0000	.0000	.0000	.0000	,0000	,0000	.0000
- ,20	,3431+03	2368-03	.1682-03	1226-03	,9124-04	,6923-04	,5342-04	,4184*04	,3393-04	,2728-04	,2217-04	,1820-04
160	,3088≈02_	2131=02	<u>+1514=02</u> .	1103=02		,6230=03	4807=03.	,37.66=03	3054=03.	,2455=03	,1996+03	1638+03
80	.1235-01	,8525-02	.6057 = 02	4412=02	,3285-02	,2492=02	,1ÿ23- <u>0</u> 2	.1506=02	,1222-02	,9821-03	,7983-03	,6553 - 03
1,00	.1513+00	.1044+00	_	_	-						9779-02	
1.20	,3827*00_	2642+00									2474=01_	
1.40	.3602+00	,2486+00	,1766+00	1287+00	9578-01						,2328-01	
1.60	.3513+00				,9343 + 01			-		•	,2271-01	
1,80	•	3069.+00			-		_				2874-01	
2.00	.1000+01				,2660+00						,6466-01	
2,20	,3268+01				•						,2112+00 ,5452+00_	
2,40	6435±01 .1601+02	•		_			•				,1035+01	
2,60		1793+02									,1679+01	
2.80	-	•	•				•				248ñ+01	
3.00			- · · · ·				•				,327å+01	
3.20		,3903+02	2773+02	+2020+02	.1504+02	,1141+02	,8805+01	.6897+01	,5594+01	,4497+01	,3655+01	,3000+01
3,40	.5711+02	3942+02	2801+02	2040+02	1519+02	1152+02	,8892+01	.6965+01	<u>,5649+01</u>	4541+01	3691+01	3030 <u>+01</u>
3,60	.5711+02	,3942+02	,2801+02	•2040+02	1519+02	,1152+02	.8892+01	.6965+01	,5649+01	.4541+01	,3691+01	,3030+01
3.80												

,1130+02 ,7981+01

4.00

IMSC. -A991396

Table 2-4 SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER DADA, HIGH PENMN - HYDROGEN SUPPLY SYSTEM

DELTA-P DUE TO LINE FRICTION AND CONFIGURATION LOSSES

4304+01

.5792+01

.3265+01

DELTA 12.0 INCH \$3.0 INCH 14.0 INCH 15.0 INCH 16.0 INCH 17.0 INCH 18.0 INCH 19.0 INCH 20.0 INCH 21.0 INCH 22.0 INCH 23.0 INCH MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE TIME .00 .1141-04 .9299-05 .7655-05 .6361-05 .1780-04 .1416-04 .1017-03 .7183-04 .5213-04 .3874=04 .2938-04 .2269=04 20. .1144-03 .9325-04 .7677-04 .6379-04 .2946-03 .2275+03 .1765-03 .1420-03 .1020-02 .7202-03 .5227+03 .3885=03 40 _2202-02 _1637-02 _1241-02 _9586-03 _7521-03 _5984-03 _4821-03 _3929-03 _3234-03 _2688-03 4298-02 3035-02 160 .7717-02 .5734-02 .4349-02 .3359-02 .2035-02 .2096-02 .1689-02 .1376-02 .1133-02 .9416-03 .1906-01 .1063-01 80__ ,8101-02 ,6446-02 ,5193-02 ,4232-02 ,3484-02 .2895-02 ,2372-01 ,1763-01 ,1337-01 .1033=01 4629-01 3269-01 1:00 .8763-01 .6512-01 .4939-01 .38:4-01 .2992-01 .2381-01 .1918-01 .1563-01 .1287-01 .1069-01 1710+00 1207+00 1.20 .1155+00 ,9058+01 .7207+01 .5806-01 .4732+01 .3895+01 .3237+01 .1495+00 .5176+00 .3655+00 .2653+00 +1971+00 1.40 .8212-01 .6692-01 .5509-01 .4578+01 .1633+00 ,1281+00 ,1019+00 .3752+00 .2788+00 .2115+00 .7321+pp .5169+pp 1.60 1614+00 1266+00 1007+00 8116-01 6613-01 5445-01 4524-01 .7235+00 .5108+0n .3707+00 .2755+00 .2090+00 1.80 1207+00 ,1207+00 9728-01 .7928-01 .6526-01 .5423-01 .2505+00 .1934+00 .8672+00 .6123+00 .4444+00 ·3303+00 2.00 .3213+00 .2521+00 .2006+00 .1616+00 .1317+00 .1084+00 .9008=01 .1440+01 .1017+01 .4161+00 .7382+00 .5486+00 2.20 .9307+00 .7059+00 .5451+00 .4277+00 .3403+00 .2742+00 .2234+00 .1839+00 .1528+00 .2444+01 .1726+01 .1252+01 2.40 1575+01 ,1195+01 ,9228+00 ,7239+00 ,5760+00 ,4641+00 ,3782+00 ,3113+00 ,2587+00 4137+01 ,2921+01 .2120+01 2.60 .2731+01 .2071+01 .1599+01 .1255+J1 .9983+00 .8044+00 .6555+00 .5396+00 .4484+00 .7170+01 .5063+01 3675+01 2.80 .3840+01 .2912+01 .2249+01 .1764+01 .1404+01 .131+01 .9217+00 .7588+00 .6305+00 ,1008+02 ,7119+01 .5167+01 3.00 ,2508+01 ,1968+01 ,1566+01 ,1262+01 ,1028+01 ,8463+00 ,7033+00 .1125+02 .7941+01 .5763+01 .4283+01 .3248+01 3,20 .4300+01 .3261+01 .2519+01 .1976+01 .1572+01 .1267+01 .1032+01 .8497+00 .7061+00 ,1129+02 ,7973+01 .5786+01 3.40 .1033+01 .8506+00 .7068+00 .2521+01 .1978+01 .1574+01 .1268+01 1130+02 17981+01 .5792+01 4304+01 .3265+01 3.60 .1268+01 .1033+01 .8506+00 .7068+00 .2521+01 .1978+01 .1574+01 .43G4+01 .3265+01 .1130+02 .7981+01 .5792+01 3.80.. ,2521+01 ,1978+01 ,1574+01 ,1268+01 ,1033+01 ,8506+00 ,7068+00

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

	DELTA-P TO S	SUPPLY ACCELE	RATION HEAD		DELTA-P DUE	TO LINE FRICT	ION AND CONFI	GURATION LO
ELTA IME	ENGINE LINE NO 1	ENGINE	ENGINE LINE NO 3	ENGINE LINE NO 4	ENGINE LINE NO 1	FIGINE NO 2	ENGINE LINE NO 3	ENGINE LINE VO 4
-+00	,00000000	.00000000	,00000000	.00000000	.00000000	,0000000	.00000000	,00000000
,20	.417691£0-01	.76351536m01	.,98341784901	_4.000000000	.51065396=05	167791624+05	.78310665-05	_000000000
40	,41769109-01	,76351536=01	,98341782=01	.00000000	,45958857#04	,61012462#04	,70479599=04	,00000000
-+60	,83538221-01	.15270308	:19668357	.000000000	,18383543=03	,24404985#03	.28191840-03	,00000000
.80	54299843	. 99256998	1,2784432	00000000	22519839=02	_129896106=02	_,34535003=02	_,000000000_
1.00	-,25061462-01-	,45810915-01	.59005060701	.00000000	,56966513=02	,75625624±02	,87360246-02	.00000000
-, 20	m.16707646-01-	,30540619+01	-,39336719#01	.00000000	,53606410=02	,71164935=02	,82207404=02	.00000000
.40		.00000000	.00000000	00000000	52290966#02	69418623=02.	80190120=02	_,00000000_
160	.16707643	,30540613	,39336711	.00000000	.66180752#02	:87857944±02	.10149062-01	.00000000
., 80	,58476748	1,0689214	1,3767848	.00000000	.14890669=01	,19768 ₀ 38=01	,22835390=01	.00000000
• 00	1.2363657	2,2600056	2,9109170	_,00000000	,48643671901	_+64576673m01_	.74596860=01	,00000000
20	1,2363655	2,2600053	2,9109165	.00000000	.12555061	,16667411	.19253648	,00000000
40	1.2363657	2,2600056	2,9109170	.000000000	,23825071	,31628860	,36536624	,00000000
1:60	1.2363655	2,2600053	2,9109165	000000000	,38674399	.51342013	59308614	_,000000000
,80	1.2363657	2,2600055	2,9109168	.00000000	.57103042	,75806872	87569617	,00000000
.00	,83538232	1,5270310	1,9668359	.00000000	,75298991	,99962818	1,1547378	.00000000
,20	83538133-01	.15270291	19668336	00000000	.84174157	1.1174500	1.2908417	.00000000
40	.0000000	.00000000	.00000000	.00000000	.85005499	1,1284865	1.3035906	,00000000
1.60	.00000000	.00000000	,00000000	.00000000	.85005499	1,1284865	1,3035906	,00000000
.80	00000000	.00000000	.00000000	03000000	.85005499	1,1284865	1.3035906	.00000000

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

	DELTA-P TO	SUPPLY ACCELES	RATION HEAD		DELTA-P DUE	TO LINE FRICT	ION AND CONFI	GURATION LO
ELTA IME	ENGINE Line no 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4	ENGINE LINE NO 1	ENGINE LINE NO 2	ENGINE LINE NO 3	ENGINE LINE NO 4
•20	•	.14557779=01 .16984076=01	•		•	•	,67352826-05 ,67539917-04	•
• 40 • 60	,	.31541854=01	•	•			,28456569#03	
,80	,30700298-01	.50952227#01	,85952330#01	,00000000	.47952643=03	,75199678±03	,99700893=03	,00000000
,00		B2494083±01		00000000		•	_130653019 <u>=</u> 02	
. 20	,122801[9	,20380890	,34380931	,00000000			,11322010=01	
40	,14326806 -,24852625-01	.23777706 41247046=01:	40111087	.00000000	•	•	.34272112=01 .48471770=01	
60.		,33968156+01					.47902078#01	
.00	,49705238=01	.82494070=01	13916090	.00000000	.27617627=01	,43310160=01	.57421277-01	.00000000
20	18420180		<u> 51571401 </u>	00000000			<u> 195378337•01</u>	
40	,13157269	,21836666	136836708	,00000000	77827437=01	·	,16181517	.00000000
60	,27776463 ,28215033	,46099638 ,46827518	177 ⁷ 66400	.00000000	,13174604 ,22834861	,20660508 ,35809793	127392020 147477176	.00000000
.80	,15057766	24990856	.42157574	.00000000	.32109293	,50354023	,66760140	.00000000
.0 <u>0</u>	·	.72788867-02			,35813983	156163745	,74462758	00000000
40	,00000000	.24263012 <u>+02</u>	.00000000	*00000000	,35957742 ,35993727	,56389189 ,56445621	.74761635 .74836475	.000000000.
60	.0000000	.00000000	,00000000	,00000000	,35993727	,56445621	,74836475	.00000000
.80	.00000000	.00000000	00000000	.00000000	,35993727	,56445621	,74836475	.00000000

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - OXYGEN SUPPLY SYSTEM

ULLAGE PRESSURE REQUIRED FOR 3 ENGINE OPERATION

			ULLAGE PRE	ESSURE REG	JIRED FOR	3 ENGINE	OPERATION					
DELTA	12:0 INCH MAIN LINE	13.0 INCH MAIN LINE	14.0 INCH									
.00	⊎11.486	-11,486	-11,486	=11,486	-11,486	-11.486	=11,496	#11,486	- 11,486	*11.486	-11:486	-11,486
140	-8.753	#9,142	-9,452	₹9.701		• •		#10,337	=10,439	*10,528	-10.604	-10,671
,60	#8.750 -6.006		-7,411	-7.912	<u>*9,905</u> -8,321			#10,336 #9,185	<u>*10.439</u> -9.391	-9.567	<u>+10.604</u> -9.720	710,67 <u>0</u>
03,		19,090	15,039	11,775	9,106			3,480	2,144	,995	-:001	-,870
1,00	312.682	=12,567	-12,458	=12.359	=12.271	-12:184	•	#12.068 _	-12,015	-11.270	-11:929	*11.874
i_40	=12.176	•12,132	+12,080	-12,028	-11,980			#11,659	-11,826	*11,798	-11:773	+11.750
1,60	#11:122 	=11,231 	-11,301 	#11,348 <u>#4,171</u>	=11.380 =5.029			=11,430 =6,817	•11,438 <u>-7,238</u>	-11,445 -7,599	-11.450 -7.911	*11,455 <u>*6,183</u>
1.80	27.815	22.047	17.517	13,890	10.940		61474	4,760	3,302	2,048	:963	.018
2,20	72.780	60,227	50,421	42,600	36,256		•	23,024	19,915	17,241	14.930	12.918
2,40	78+072 85+825	63,923 69,328	53,079. 56,974	44,570 47,456	37.,755 39.950		•,	23,77 <u>9</u> 24,883	20,551 21,481	17.776 18.550	15.388 16.059	13,316_ 13,900
2,60		76,452	62,105	51,259	42,842	·		26,339	22,707	19,592	16.943	14,668
3.00	108:718	B5,294	68.473	•	46.430	•	•		•	20.873	18.039	15,621
3.20	94.996	71,527 33,609	55,232 21,690	43,505	34,802			18,895 -,916	15,680	12,935	10.653	8,733 =5,480
3,40	47.029	29,336	17.924		5.105			-3.118		-5,541	-6:392	<u>•7,053</u>
3,6Q 3,8G	47:045	29,352	17.940	10,335	5,121	1:457	*1,175	-3,102	-4,418	•5,525	-6:376	-7,037
	47.061	29,368	17,956	10,351	5,137	1,473	#1,159	-3,086	-4,402	-5,509	-6.360	47,021

IMSC-A991396

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE + ORBITER 040A, HIGH PENMN + HYDROGEN SUPPLY SYSTEM

ULLAGE PRESSURE REQUIRED FOR 3 ENGINE OPERATION

DELTA 12.0 INCH 13.0 INCH 14.0 INCH 15.0 INCH 16.0 INCH 17.0 INCH 18.0 INCH 19.0 INCH 20.0 INCH 21.0 INCH 22.0 INCH 23.0 INCH TIME MAIN LINE
,00	30.522	30,501	30,484	30,470	30.459	30:450	30,442	30,436	30,430	30,425	30:421	30,417
20	30.551	30,526	30,506	30,490	30,477	30,466	30,457	30,449	30,443	30,437	30.432	30,428
• 40	30.723	30,676	30,638	30,608	30.584	30.563	30,546	30,532_	30,520	30.509	30.500	30,492
•60	30.959	30,880	30,818	30,768	30,728	30.695	30,657	30,643	30,623	30,606	30,592	30,579
80	31,357	31,223	31,118	31,035	30,968	30,912	30,866	30,827	30,794	30,766	30.742	30,721
1.00	52.892	32,544	32,275_	32,062		31.750	31,633	31,536	31,453	31,382	31 321	31,268
1.20	33,655	33,155	32,780	32,489	32,260	32:075	31,924	31,798	31,693	31,603	31.527	31,461
.1,40	30.679	30,524	30,430	30,373	30,337	30,315	30,302	30,294	30,290	30,288	30.288	30.289
1,60	31,519	31,257	31.077	30,950	30,858	30,788	30,736	30,694	30,662	30,636	30.614	30,576
1.80	32,233	31,858	31,594	31,403	31,260	31,151	\$1,065	30,997	30,942	30.897	30.859	30,828
2.00_	35.425	34,556	33,922	33,447	33.080	32,792	32,560	32,371	32,215	32,084	31.973	31.878
2,20	35.486	34,449	33,723	33,197	32.805	32,506	32,272	32,086	31,936	31,814	31,711	31.626
2:40	40+097	38,208	36,872 .	35,897	35,163	34,599	34,195	33,800	33,511	33,273	33.074	32,906
2:60	43,416	40,625	38,694	37.312	36,294	35,525	34,932	34,465	34,091	33,787	33,537	33,329
2,80	43,998	40,669	38,428	36,867	35,748	34,926	34,309	33,836	33,467	33,175	32,941	32,750
3,00	42.434	39,118	36,932	35,445	34,405	33,661	33,116	32,711	32,404	32,168	31,984	31,839
3120	42.427	39,105	36,916	35,428	34.387	33,643	231048	32,694	32,388	32,152	31.969	31,825
3,40	42,412	39,091	36,902	35,414	34.375	33,631	33,088	32,684	32,378	32,143	31,961	31,817
3,60	42.413	39,092	36,903	35,415	34,376	33,632	221098	32,685	32,379	32,144	31.962	31,818
3,80	42.414	39,093	36,904	35,416	34,377	33,633	23,090	32,686	32.380	32,145	31.963	31,819
4.00										-		`

Table 2-4

SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN

RANS.	ULLVAP	ULLVAP: FUEL	MINULL OXID.	MINULL	TNKBOT	TNKBOT FUEL	LINHED OXID.	LINHEDFUEL	ULLVOL	ULLVOL FUEL	TNKHED	TNYHED	ULLWGT QXID	ULLWGT FUEL
SEC	PSIA	PSIA	PSIA	PSIA	PSIA	PSIA	PSIA	P814	CU.FT.	cu.FT.	PT.	FT.	LAS	LBS
00	20,052	20,170	20,05	30,52	45,55	33,46	48,99	• , 290	607.8	1784.5	51,78	96,19	209,6	230.1
.20	20,052	_20,170	20.05	30,25_	45,55	33,49_	48.99_	290	607. 8	1784.7	51.78_	96,19	309.6	230.4
.40	20,052	20,170	20,05	30,72	45,55	33,66	48.99	-1290	607,9	1785.1	51,78	96,18	209,7	232.0
•	20.052	20,170	20,05	30.96	45,55	33,90	48,99	=1290	608,0	1785.8	51,78	96,18	209,7	234,1
.80	20,052.	20.170-	24,20_	_31,36_	49.,70	34,29_	48,99_		608.4_	1787,1_	51,78_	96,18_	255.1	237,8
1.20	20,052	20,170	20,05	32,89	45,55	35,83	48,99	=:2 90	609.0	1789.6	51,78	96,18	216,1	251.8
	20,052	20,170	20.05	33,65	45,54	36,59	48,99	-,290	609,7	1794.0	51,78	96,17	210,3	259.2
1,40	20.052_	20,170	20.05_	30,68_	45,54_	33,61_	48,99	<u> 7+290</u>	610.3_	1799.1	51,77	96,16	<u> 210.5</u>	253.4
1,60	20,052	20,170	20.05	31,52	45,54	34,45	48,99	* 290	610,9	1804,3	51,77	96,15	216,7	241.6
	20.052	20,170	27.81	32,23	53.30	35,17	48.99	# 1290	612.0	1809,9	51,77	96,14	296.7	248,8
2,00	20.052	_:20,170	72,78_	35,43_	98.26_	38,36_	48,99	=+270_	613,8_	1817.2	51,76	96,13_	857.5	27.8.6
2,20 2,40		20.170	78.07	35,49	103,55	38,42	48,99	-,290	616.8	1826.6	51,75	96,11	929.2	280.6
	20.052	20,170	85,83	40.10	111.29	43,03	48,99	-1290	620,9	1838,9	51,73	96,09	1047.8	324,6
2,60	20.052_	_20,170.	96.04	43,42	_121.50_	46.35_	48.99	= :290	626,1_	1855.1_	51,71	96.06	_1214.3_	358,0
2,80	20.052	20,170	108,72	44,00	134.16	46,93	48,99	e:290	632,4	1874,3	51,68	96,03	1440.2	367,1
3,00	20.052	20,170	95,00	42,43	120,42	45,36	48,99	-,290	639,7	1894,6	51,65	95,99	1223.7	356.4
3,20	20.052	20.170	51,91_	42.43	77.32	45,36	48.99	±1290	647.3	1915.0	51.61_	95,96	612.7	360.1
3,40	20,052	_	47.03	42,51	72,43	45,34	48.99	#12¥0	655.0	1935,3	51,58	95,93	556,4	363,8
3,60	20.052	20,170	47,05	42.41	72.43	45,34	48,99	#12YO	662,8	1955.6	51,55	93,89	563.1	367.7
3,80	20.052	20.170	47,06	42,41	72.43	45.34	48.99	<u>=1290</u>	670.5	1976.0	51,52	95,86	509.9	371.5

4.00

IMSC-A991396

Table 2-4 SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - OXYGEN SUPPLY SYSTEM

MINIMUM REQUIRED ULLAGE PRESSURE FOR 3 ENGINE OPERATION PER MAIN FEED LINE

		HISTORIUM IN	EROTUED OF	LAVE FRESS	UNE FUR >	EMOTIVE OF	CUMITAL P		20 8 1 T Se	-		
DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE	14,0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18,0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN L'INE	23.0 INCH MAIN LINE
.00	20.052	20,052	20.052	20,052	20.052	20,052	201025	20,052	20.052	20.052	20:052	20.052
	20.052	20,052	20,052	20,052	20.052	20.052	20,052	20,052	20,052	20.052	20.052	20,052
140	20.052_	20,052	20,052	20,052	20.052	20.052	30,045	20,052	20,052	20,052	20:052	20,05
,60	20.052	20,052	20.052	20,052	20.052	20.052	20,052	20,052	20,052	20,052	20:052	20.05
80	24.205	20,052	20.052	20,052	20,052	20.052	20,092	20,052	20,052	20,052	20.052	20,052
1,00	20.052_	20,052	20.052	20.052	20.052	20.052	20,022	20,052	20.052	20.052	20,052	20.052
1,20	20:052	20.052	20,052	20,052	20.052	20.052	201025	20.052	20,052	20,052	20:052	20.052
	20,052	20.052	20.052	20.052	20.052	20.052	20,052	20,052	20,052	20.052	20.052	20.052
1.60	20.052	20.052	20,052	20,052	20.052	20.052	50.025	20,052	20,052	20,052	20,052	20,052
1,80	27.815	22.047	20.052	20,052	20.052	20:052	20,032	20.052	20,052	20,052	20:052	20.052
2.00	72.780	60,229	50,421	42,600	36,256	31.037	501698	23,024	20,052	20.052	20.052	20,052
2,20	78.072	63,920	53,079	44,570	37,755	32,203	27,616	23,779	20,551	20,052	20:052	20,052
2,40	65,825	69,328	56,974	47,456	39,950	33,913	28,977	24,883	21,481	20.052	20:052	20.052
2,60	96.041	76,452	62,105	51,259	42,842	36,165	30,759	26,339	22,707	20.092	20.052	20,052
2,80	108.718	85,294	68,473	55,978	46,430	38,959	32,993	28,145	24,227	20,873	20:052	20,052
3,00	94.996	71,527	55,232	43,505	34.802	28,171	23,003	20,052	20,052	20,052	20:052	20,052
3,20	51.909	33,609	21,690	20,052	20.052	20.052	20,052	20,052	20,052	20.052	20.052	20,052
3 , 40	47.029	29,336	20,052	20,052	20,052	20,052	201025	20,052	20,052	20,052	20:052	20,052
3.60	47.045	29,352	20.052	20.052	20.052	20.052	20,052	20,052	20.052	20.052	20:052	20.052
3,80	47.061	29,368	20,052	20,052	20,052	20.052	201025	20,052	20,052	20.052	20.052	20,052
4 40											,	

31,819

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

		MINIMUM R	EQUIRED UL	LAGE PRESS	URE FOR 3	ENGINE OP	ERATION PE	R MAIN FEE	D LINE			
DELTA Time	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE										
.00	30.522	30,501	30,484	30,470	30,459	30,450	30,442	30,436	30,430	30,425	30:421	30,41
	30.551	30,526	30,506	30,490	30,477	30,466	30,457	30,449	30,443	30,437	30.432	30,42
,40	30.723	30,676	30,638	30,608	30,584	30,563	30,546	30,532	30,520	30.509_	30:500	30,492
.60	30.959	30,880	30,818	30,768	30,728	30,695	30,667	30,643	30,623	30.606	30.592	30,579
80	31.357	31,223	31,118	31,035	30,968	30:912	30,866	30,827	30,794	30,766	30:742	30,72
1.00	32.892	32,544	32,275	32,062	31,890	31.750	31,633	31,536	31,453_	31,382	<u>31:321</u>	31,26
1,20	33,655	33,155	32,780	32,489	32,260	· 32.075	31,924	31,798	31,693	31,603	31.527	31,46
1.40	30.679	30,524	30,430	30,373	30.337	30,315	30,302	30,294	30,290	30.288	30.288	30,28
1:60	31,519	31,257	31,077	30.950	30.858	30,788	20,726	30,694	30,662	30.636	30.614	30,59
1,80	32,233	31,858	31,594	31,403	31,260	31,151	31,065	30,997	30,942	30.897	30.859	30,82
2.00	35,425	34,556	33,922	33,447	33,080	321792	\$2,560	32,371	32,215	32.094	31.973	31,87
2.20		34,449	33,723	•	•			32,086	31,936	31,814	31:711	31,626
2.40	40.097	38,208	36,872		•		34,135	33,800	33,511	33,273	33:074	32,900
2,60		40,625	38,694			35,525	34,932	34,465	34.091	33,787	33.537	33,329
2,80		40,669	38,428						33,467	33,175	32:941	32,750
3.00	•	39,116	36,932			33,661	33,116	32,711	32,404	32,168	31:984	31,839
3:20		39,105	36,916						32,388	32,152	31:969	31,82
3,40		38,091	36,902	:	•					32:143		31,81
3,60	_	39,092	36,903						32,379	32,144	31:962	31,816
3,80		30 20-	34 004	38 444	34 377			32.686	32.380	32.145	31 '043	31 810

33.633

34,377

36,904

35.416

33,090

32,686

32,380

32,145

31,963

4,00

54,732

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

•	SAMPLE CASE - ORBITER 040A, HIGH PENMN OXYGEN SUPPLY SYSTEM
	TANK BOTTOM PRESSURE VALUES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA 12:0 INCH 13:0 INCH 14:0 INCH 15:0 INCH 16:0 INCH 17:0 INCH 18:0 INCH 19:0 INCH 20:0 INCH 21:0 INCH 22:0 INCH 23:0 INCH MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE MAIN LINE .00 45:549 45,549 45,549 45,549 45,549 45.549 45,549 45.549 45.549 45.549 45,549 45.549 ...20 45.549 45,549 45,549 45,549 45,549 45.549 45,549 45,549 45.549 45,549 45,549 45,549 . 40 _45,548_ 45.548 45,548 45.548 45.548..... 45,548... 45.548. 45.548_ 45.548 45,548... 45.548 45.548_ ,60 45.548 45,548 45.548 45,548 45.548 45,548 45,548 45,548 45,548 45.548 45,548 45,548 .. , 80 45,547 45,547 49.700 45,547 45,547 45,547 45.547 45,547 45,547 45,547 45,547 45,547 1.00 45.546 45,546 45.546 45 546 45.546 45.546_ 45.546_ 45.546 45,546 45.546.... .45.546.... 45,546_ 1,20 45,545 45.545 45,545 45,545 45.545 45,545 45.545 45.545 45.545 45.545 45,545 45.545 11.40 ._ 45,543 45,543 45,543 45,543 45,543 45,543 45.543 45,543 45,543 45,543 45,543 45,543 1.60 45,542 45,542 45,542 45,542 45,542 45,542 45.542 45,542 45,542 45,542 45,542 45,542 1.80 45.540 45,540 47,535. 45,540 45,540 45.540 45,540 45,540 45,540 45,540 45,540 53.302 2.00_ 45.536 45,536 98.264 85,713 75,905 68,083 61,740 56,520 22:171 48,508 45,536 45,536 2,20 45 529 45,529 45,529 89,397 78,556 70.047 63,232 57,681 53,094 49,256 46,028 103.549 2.40 45.521 45,521 111.294 94,796 82,442 72,925 65,418 59.381 54,445 50,352 46,950 45,521 2,50 45.510 45,510 26,226 51,796 48,164 45,510 121,498 101,910 87,563 76,716 68,299 61,622 2.80 45,496 45,496 38,437 53,589 49,671 46.317 134 - 162 110,738 93,917 81.422 71,874 64.403 3,00 45:481 45,481 48,432 45,481 45,481 45,481 96,956 60,661 68,934 60,231 53,600 120,425 3,20__ 45 465 45,465 45,465 45,465 45,465 45,465 45,465 45,465 77.321 59,021 47,103 45,465 3,40 45,449 45,449 45,449 45,449 45,449 45,449 54,732 45,449 45,449 45,449 72.426 45,449 3,60 45,432 45.432 45,432 45,432 45,432 45.432 45.432 45,432 72.426 54,732 45,432 45,432 3.80 ...

45,416

45,416

45,416

45,416

45,416

45,416

45,416

45,416

IMSC-A991396

45,416

45,416

IMSC-A991396

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

		TANK BOTT	OM PRESSUR	E VALUES F	OR 3 ENG!	NE OPERATI	ON PER MAI	N FEED LINE				
DELTA TIME	12:0 INCH MAIN LINE	13.0 INCH	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17:0 INCH MAIN LINE	18.0 INCH MAIN LINE	19.0 INCH MAIN LINE	20.0 INCH	21.0 INCH MAIN LINE	MAIN LINE	MAIN LINE
.00.	33,458	33,437	33,420	33,407	33,395	33,386	33,378	33,372	33,366	33,362	33,357	33,354
	33,487	33,462	33,442	33,426	33,413	33,403	33,393	33,386	33,379	33,374	33,369	33,36
.40	33.659	33,612	33,575	33,544	33,520	33,500	33,483	33,468	33,456_	33.446	33:436	33.429
60	33,895	33,816	33,754	33,705	33,664	33,631	33,603	33,580	33,560	33,543	33.528	33,515
+ 8 Q	34,293	34,159	34,054	33,971	33,904	33,848	33,802	33,764	33,731	33,702	33.678	33,657
1.00	35.828	35,480	35,211	34,998	34,826	34,686	34,592	34,472	34,389_	34.318	34.257	34,204
1,20	36.591	36,091	35,715	35,425	35,195	35,011	34,859	34,734	34,629	34,539	34:463	34,397
-1-40-	33.615	33,460	33,366	33,308	33,272	33,250	33,237	33,229	33,226	33,224	33:224	33,225
1,60		34,192,	34,012	33,885	33,793	33.724	33,671	33,630	33,597	33,571	33.549	33,532
1,80	35.168	34,793	34,529	34,338	34,195	34.086	34,000	33,932	33,877	33,832	33,794	33,76
2.00	38,360	37,490	36,857	36,381	36,015	35,726	35,495	35,306	35,149	35.018	34,908	34,81
2:20	38.420_	37,383	36,657	36,131	35.739	35,440	25,206	35,020	34.871	34.748	34 646	34,560
2.40	43+030	41,141	39,806	38,830	38,097	37,532	37,038	36,733	36,444	36.206	36:007	35,839
2:60	46.349	43,557	41,626	40.244	39.227	38,458	37,864	37,397	37,024	36,720	36.470	36,262
2,80	46,929_	43,601	41,359	39,798	38,680	37,858	37,240		<u>36,399</u>	36,107	35,872	35,68
3,00	45,365	42.049	39,863	38,376	37.336		-	35,641	35,334	35,098	34,915	34,770
3,20	45.357	42,035	39,846	38,357	37,317			35,623	35,317	35.082	34.899	34,754
3,40		42.019	39,831						35,306	35.072		34,745
3,60	45.341	42,019	39,831	38,343				35,612	35,306	35.072	34.889	34,749
3,80	45.341	42,019	39,831	38,343	37,303	36,559	36,016	35,612	35,306	35.072	34.889	34,749

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE - ORBITER 040A, HIGH PENMN - OXYGEN SUPPLY SYSTEM

RECOMPUTED ENGINE PRESSURES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN/LINE	14.0 INCH MAIN LINE	15.0 INCH MAIN LINE	16.0 INCH MAIN LINE	17.0 INCH MAIN LINE	18,0 INCH MAIN LINE	19,0 INCH MAIN LINE	20.0 INCH MAIN LINE	21.0 INCH MAIN LINE	22.0 INCH MAIN LINE	23.0 INCH MAIN LINE
.00	94.539	94,539	94,539	94,539	94,539	94,539	94,539	94,539	94,539	94,539	94,539	94,539
.40	91.805	92,195	92,504	92,754	92,958	93,127	À21508	93,389	93,491	93,580	93.656	93,723
,	91,802	92,192	92.502	92,752	92.957	93,126	93,268	93,388	93,491	93,579	93:656	93,722
,60	89.059	89,842	90,463	90.964	91,373	91,713	91,997	92,237	92,443	92,619	92:772	92,906
80.	63.000	63,962	68,013	71,277	73,946	76.156	78,007	79,572	80,908	82,057	83.053	83,922
1.00	95.734	95,619	95,510	95,411	95,323	95.246	95,179	95,120	95,067	95.022	94.982	94,946
1:20	95.228	95,184	95,132	95,081	95.032	94,987	94,947	94,911	94,878	94.850	94.825	94.802
1.40	94.174	94,283	94,353	94,400	94,432	94,454	94,471	94,482	94,491	94,497	94.503	94,507
1,60	<u>83:143</u>	84,840	86,166	87.224	58.081	88.787	89,374	89.870	90,290	90,651	90:964	91,235
1.80	63.000	63,000	65,535	69,162	72.112	74,546	76,578	78,292	79,,750	51,004	82.089	03,035
.8:00.	63.000	63,000	63,000	63,000	63,000	63,000	03,000	63,000	63,137	65,811	68.122	70,134
2.20	63,000	63,000	63,000	63.000	63.000	63.000	63,000	63,000	63,000	65,276	67:664	69,736
2,40	63.000	63,000	63,000	. 63,000	63,000	63,000	93,000	63,000	63,000	64,492	66,993	69,152
.2 (.60.	63.000	63,000	63,000	63,000	63,000	63,000	03,000	63,000	63,000	63,460	56.110	68,384
2.80	63,000	63,000	63,000	63.000	63,000	63,000	63,000	63,000	63,000	63,000	65 013	67,431
13,00	63.000	63,000	63,000	63.000	63.000	63.000	63,000	64,157	67,372	70.117	72:399	74,319
3,20.	63,000	63,000	63,000	69,392	74,963	78,930	81,820	83,968	85,476	86,749	87,744	88,532
3,40		63,000	65,128		77.947	81.611	84,243	86,170	87,486	88 594	89:444	90,105
3,60	63.000	63,000	65,112		77,931			86,154	87,470	88,577	89.428	90.089
3.89. 4.00	63.000	63,000	65,096	72.701	77.915	81,579	84,211	86,138	87,454	88,561	89.412	90.073

IMSC-A991396

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

SAMPLE CASE + ORBITER 0404, HIGH PENMN + HYDROGEN SUPPLY SYSTEM

RECOMPUTED ENGINE PRESSURES FOR 3 ENGINE OPERATION PER MAIN FEED LINE

DELTA TIME	12.0 INCH MAIN LINE	13.0 INCH MAIN LINE						19,0 INCH MAIN LINE				
,00	33.000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000
+20		33,000	33,000	33,000					33,000	33,000		
•40	33.000_	33,000	33,000	33,000		33,000			33,000.	33.000	33:000	
.60	33,000	33,000	33,000	33,000		33.000		33,000	33,000	33,000	33:000	33,000
80	33.000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	53,000	33:000	33,000
1.00	33.000	33+000	33,000	33,000	33,000	33.000	3,000	3,000_	33,000	33.000	33:000	33.000
1,20	33,000	33,000	33,000	33,000	33,000	33,000	\$3,000	33,000	33,000	33.000	33:000	33,000
1:40-	33,000	33,000	33,000	33,000	33,000	33.000	33,000	33,000	33,000	33.000	33:000	33,000
1.60	33,000_		33,000	33,000	33,000	33,000	ַסְיִסּיִּלְּבֶּ	33,000	33.000	33.000	33:000	33,000
1.80	33.000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33:000	33,000
2+00-	33.000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33,000	33.000	33.000	33,000
2.20	33.000_	33,000	33,000	33,000	33.000	33,000	33,000	33.000	33.000	33.000	33:000	33,000
2,40	33,000	33,000	33,000	33,000	33,000	33.000	23,000	33,000	33,000	33,000	33.000	33,000
2,60	33,000	33,000	33,000	33,000	33.000	33.000	33,000	33,000	33,000	33,000	33.000	33,000
2.80	33,000.	33.000	33,000	33,000	33.000	33.000	531000	33,000	33,000	33,000	33.000	33,000
3.00	53,000	33,000	33,000	33.000	33.000	33.000	33,000	33,000	33,000	33.000	33:000	33,000
3+20	33.000	33,000	33,000	33,000	33,000	33,000	\$3,000	33,000	33,000	33,000	33:000	33,000
3,40	33.000_	33.000	33,000	33.000	33.000	33,000	23,000	33,000	33,000	33.000	33:000	33,000
3,60	53.000	33,000	33,000	33,000	33.000	33.000	33,000	33,000	33,000	33,000	33:000	33,000
3,80	33,000	33,000	33,000	33,000	33,000	33.000	33,000	33,000	33,000	33,000	33,000	33,000

MSC-A991396

Table 2-4
SOPSA OUTPUT DATA LISTING (CONT'D)

,	MAIN _FEEDLINE	EN	GINE FEEDL	INE WEIGHT	S	TOTAL ENGINE	MAIN	ENGINE	MAIN _FEEDLINE	TOTAL
PROPELLANT	DIAMETER (INCHES)	1NE 10 1	NO S TINE	LINE	LINE NO 4	FEEDLINE WEIGHT	FEEDLINE WEIGHT	INSULATION WEIGHT	INSULATION WEIGHT	FEED SYSTEM
OXYGEN	12,000	282,78	289,75	294.18	.00000	866.71	1341,9	15,585	72,077	2296,2
CXYGEN	13,000	282,46	288,95	293,08	.00000	864,49	1565,4	15,585	78,322	2524,8
OXYGEN	14,000	282,46	288,95	293,08	00000	864.49	1823,6	15,585	84,631	2793.3
OXYGEN	15,000	282,46	288,95	293,08	00000	864.49	2123,0	15,585	91.002	3091.0
OXYGEN	16:000	_282.46	288.95	293.08	00000	864,49,	2445,4	15,585	97,436	3423.0
OXYGEN	17,000	282,46	288,95	293.08	00000	864.49	2813,1	15,585	103,93	3797,1
OXYGEN	18,000	282,46	288,95	293,08	00000	864,49	3216,6	15,585	110,49	4207.2
OXYGEN	19:000	282,46	288.95	293.08	00000	864,49	3657.7	15,585	117,12	4654,9
OXYGEN	20,000	282,46	288,95	293.08	00000	864.49	4137,9	15,585	123,80	5141.8
OXYGEN	21,000	282,46	288,95	293.08	00000	864.49	4659 0	15,585	130,55	5669.7
GXYGEN	22:000	282.46	288,95	293.08	00000	864.49	5222.7	15,585 _	137_36	6240.2
OXYGEN	23,000	282,46	288,95	293,08	,00000	864,49	5830,7	15,585	144,24	655.0
HYDROGEN	12,000	291,08	252,21	331,46	.00000	874.75	711.31	.00000	.00000	1586,1
HYDROGEN	13.000	291,08	252,21	331,46	.00000	874.75	871.90	.00000	.00000	1746.7
HYDROGEN	14:000	291.08	252.21	331,46	00000 _	874,75	105/.0_	00000	00000	1931,8
HYDROGEN	15,000	291,08	252,21	331,46	.00000	874.75	1261,5	,00000	,00000	2143,2
HYDROGEN	16,000	291,08	252,21	331,46	.00000	874.75	1508,1	.00000	.00000	2582,9
HYDROGEN	17.000	291,08	252,21	331.46	00000	874.75	177/19	,00000	,00000	2652.6
HYDROGEN	18,000	291,08	252,21	331,46	00000	874,75	2077,8	,00000	,00000	2954,6
HYDROGEN	19,000	291,08	252,21	331,46	.00000	874.75	2418.3	,00000	.00000	3291,1
HYDROGEN	20,000	291.08	252,21	331.46	00000	874,75	2790.0	00000	00000	3664.8
HYDROGEN	21,000	291,08	252,21	331,46	.00000	874,75	3204.3	.00000	.00000	4079.0
HYDROGEN	22,000	291.08	252,21	331.46	,00000	874.75	3663,7	,00000	.00000	4534.4 5050.0
HYDROGEN	23,000	291.08	252,21	331.46	00000_	874.75		00000		

END OF CASE 2

APPENDIX A

INPUT DATA FORMATS

Propered	HAME	DATE	LOCKHEED	AIRCRAFT (ORPGRATION	Pelgo	TEMP.	PERM.
Checlad			CASE 1	TITLE CARD		Madel		
Approved			HEADEF	R CARD NO. 1	L	Repart	No.	
!	Analysis title ca This card must be Format (7A6)					t.		
-	ST(I)		·					
12241	7 6 8 10 11 12 12 14 16 16 17 16 18 17	22253773	######################################	Q 4 4 5 4 7 6 8 11 12	B M B B B B B B B B B B B B B B B B B B	8 68 67 68 69 79 71 72	77 14 25 25 75	1878
					·			
					·			
123456	7 8 5 70 fri 12 13 14 13 18 17 18 19 38 fzi	2 2 2 2 2 2 2 2 2 2 2	OMIT	43 44 48 48 47 48 48 52 11 52	15 M M N 17 M W M N 12 43 M	96 98 67 98 68 70 71 72	ז אר מז או מז	7 76 79 ao
			OMIT					·
121411	7 e 6 m/n 12 13 14 m/m 17 14 m/m/m	22353733	an na a a a a a a a a a	4444744311E		16 86 87 88 80 78 73 72	73 74 75 76 7	7 73 79 20
			·					
			OMIT			····		
111411	រន់ស្តាក់ប្រទេស នេស ប្រសេស សង្គ្រា ន		in = = > = = = = = = = = = = = = = = = =	2 4 4 4 2 4 4 M/v H 1	# 64 65 70 87 69 69 fb; 62 63 44		3 74 Th TE 71	778

Propered	NAME	DATE	LOCKHEED AIRCRAFT CORPORATION	TEMP. PERM.
		·	INPUT DATA FLAG CARD	
Checked			HEADER CARD NO. 2	Medel
Approved m	ria card contain	0.116 4.44		Report No.
gı Il	coups which foll	ow. If I	ger flags corresponding to the 16 input de $P(IG) = 1$, Data Group IG is to be read in Group IG is not present.	ata ; if
1 2 3 1 3 3	P B B 75 E1 12 13 4 15 16 17 16 19 28 2	NOTE:	THIS CARD MUST BE INCLUDED AS THE SECOND CARD IN EACH CASE	מו מר צר לד אר כל אל בנו בל ולון אר 80 מ
		. ·		
			OMIT	
123456	7 8 9 15 11 12 13 14 15 16 17 15 19 20 2	1 2 2 3 3 3 3 T 3 3	367 2 3 3 3 3 4 5 3 3 4 6 1 4 4 4 4 4 4 4 4 4 4 4 4 6 6 6 6 6	m 00 75/11 72 73 14 15 75 77 72 120
	•		OMIT	
123486	7 8 9 10 11 12 13 14 19 10 17 10 19 20 2		Mn n n n n n n n n n n n n n n n n n n	11 99 A 11 12 22 14 25 27 17 18 20 10
		(· DMIT	·
1 2 3 4 5 4 1	· « ախուսա առաջությունը	, ##########	ын жин жин я ы ы а ы а а а а а а ы ы ы ы ы ы ы ы ы	8 M N 1 1 7 7 7 7 7 7 7 7 7 7 10 00

LMSC-A991396 LOCKHEED AIRCRAFT CORPORATION MAME TEMP. PERM. Prepared FEED SYSTEM PARAMETERS Checked INPUT GROUP 1 Approved Report No. NML- Number of main feedline sizes to be considered (up to 12) NEL - Number of engine feedline attached to each main line (up to 4) SYSNUM - If 1, program computes for OXID, feedlines only. - If 2, program computes for fuel feedlines only. - If 3, program computes for both feedlines. - Total number of feedlines per tank - NEL + NML NSIZE NOP · - Number of engines FED by a main feedline NOPl - Number of engines on vehicle - Number of time points being considered in analysis (up to 20) NPTS NGST - Ground start flag (NGST = 2 for ground start) Format ((1216)). (All inputs right adjusted) NEL NML SYSNUM NOP NOPI NPTS NGST TØTLMØ - Total length of oxygen main feeding, ft. TOTIMH - Total length of hydrogen main feedline, ft. FØRMAT ((6E12.8)) TØIMLØ RIMI'OT TIMO

H	AME	DATE	Lo	CKHEED AIRCR	AFT CORPORATI	ON	~~	TEMP.	PER
	.:		TITLE	PROPELLANT	TANK CONFIGURA	TION			
				INPUT	GROUP 2		Roper	No.	
			ii of tar	nk sections (see Fig. 9)				-
1 (1)	EQLR1 (2	P) EQLI	R1 (3)	EQLR1 (4)	EQLRIL (5)	EQLR(L (6)		-
7 a 8 10 hi 12	3 4 2 16 17 16 18 28			7 3 3 ada 2 4 4 4 4 6 6	***********		44 60 70 71 7	272 14 75 7B	מו מו זו
<u> </u>					 			. .	
(7)	EQLR1 (8) EQL	RL(9)						
7 a s 10 h 1 12	12 14 15 18 17 15 18 28 <u>2</u> 8	n 22 25 25 27 21 28 28 27 21 28 28 28 28 28 28 28 28 28 28 28 28 28		733		n ez ez ea ea ea s r	M 58 70 71 1	2 B 14 B R	TI TE FE
	<u> </u>			1					
			<i>C</i> M.T.⊞			•			
7 o o whi 12 1	13 M NS NS 17 18 19 30 2	1 11 11 14 15 15 17 18			• • wist # 0 & 0 & 0 & 0 & 0	1 C2 C2 OF 16 86 87	m m 70 71 7	z 73 74 7 5 76	nnn
•							<u>. </u>		
				•					
	(7)	(7) EQLR1 (8)	Format ((6E12.8)) 1 (1) EQLR1 (2) EQL 7 3 4 9 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	EQLR1 - Lengths and Radii of tar Format ((6E12.8)) 1 (1) EQLR1 (2) EQLR1 (3) (7) EQLR1 (8) EQLR1 (9) 7.56 m/n 12 2 14 15 16 17 18 18 18 18 18 18 18 18 18 18 18 18 18	PROPEILANT INPUT EQLR1 - Lengths and Radii of tank sections (Format ((6E12.8)) 1 (1) EQLR1 (2) EQLR1 (3) EQLR1 (4) (7) EQLR1 (8) EQLR1 (9)	PROPELIANT TANK CONFIGURA INPUT GROUP 2 EQLR1 - Lengths and Radii of tank sections (see Fig. 9) Format ((E12.8)) 1 (1) EQLR1 (2) EQLR1 (3) EQLR1 (4) EQLR1 (5) (7) EQLR1 (8) EQLR1 (9) OMIT	PROPELIANT TANK CONFIGURATION INPUT GROUP 2 EQLR1 - Lengths and Radii of tank sections (see Fig. 9) Format ((&E12.8)) 1 (1) EQLR1 (2) EQLR1 (3) EQLR1 (4) EQLR1 (5) EQLR1 ((7) EQLR1 (8) EQLR1 (9) OMIT	PROPELIANT TANK CONFIGURATION INPUT GROUP 2 EQLR1 - Lengths and Radii of tank sections (see Fig. 9) Format ((6E12.8)) 1 (1) EQLR1 (2) EQLR1 (3) EQLR1 (4) EQLR1 (5) EQLR1 (6) (7) EQLR1 (8) EQLR1(9) OMIT	PROPELIANT TANK CONFIGURATION INPUT GROUP 2 Report No. SQLR1 - Lengths and Radii of tank sections (see Fig. 9) Format ((6E12.8)) 1 (1) EQLR1 (2) EQLR1 (3) EQLR1 (4) EQLR1 (5) EQLR1 (6) (7) EQLR1 (8) EQLR1 (9) OMIT

LMSC-A991396 LOCKHEED AIRCRAFT CORPORATION HAME DATE Prepared OXIDIZER FEEDLINE CONFIGURATION Checked INPUT GROUP 3 Approved A Report No. MIDMLO - TOTAL NUMBER OF COMPONENTS IN MAIN OXYGEN FEEDLINE (UP TO 100) MIDELO(NL) - TOTAL NUMBER OF COMPONENTS IN ENGINE OXYGEN FEEDLINE NUMBER NL (UP TO 100) IDMLO - COMPONENT TYPE FLAG FOR MAIN OXYGEN LINE IMMLO - COMPONENT MATERIAL FLAG FOR MAIN OXYGEN LINE IIMLO - COMPONENT INSULATION FLAG FOR MAIN OXYGEN LINE IMLO - SUBSCRIPT DENOTING COMPONENT POSITION IN MAIN OXYGEN FEEDLINE (IMLO = 1 AT TANK BOTTOM) IELO(NL)-SUBSCRIPT DENOTING COMPONENT POSITION IN ENGINE OXYGEN FEEDLINE (IELO(NL) = MIDELO(NL) AT INLET TO ENGINE NO. NL) SP1MLO(I), SP2MLO(I), SP3MLO(I) - COMPONENT SPECIFICATIONS (SEE MANUAL) OPD(K), K=1, NEL - DIAMETERS OF OXYGEN ENGINE FEEDLINES (INCHES) OPD(K), K-NEL+1, NSIZE - CANDIDATE DIAMETERS OF MAIN OXYGEN FEEDLINE (INCHES) FORMAT((1216)) (FIRST CARD) COMPONENT COUNT CARD MIDELØ(MIDMIN COMPONENT DESCRIPTOR CARDS FOR MAIN FEEDLINE (THERE MUST BE MIDMLO OF THESE CARDS) FORMAT(316,3E12.8) IMMI COMPONENT DESCRIPTOR CARDS FOR EACH ENGINE FEEDLINE (THERE MUST BE MIDEL O(NL) OF THESE CARDS FOR EACH ENGINE FEEDLINE NO'S 1 TO NEL) FORMAT (316,3E12.8) LIELØ

LMSC-A991396 LOCKHEED AIRCRAFT CORPORATION Propered TITLE OXIDIZER FEEDLINE CONFIGURATION Chocked INPUT GROUP 3 (Continued) Approved Oxidizer Feedline Diameter Cards Format ((6E12.8)) NSIZE z NEL + NML OPD (1) OPD(NEL) OPD(NEL+1) OPD(NSIZE) -ENGINE FEEDLINE DIAMETERS - MAIN FEEDLINE DIAMETERS TIMD TIMO OMIT

LOCKHEED AIRCRAFT CORPORATION Prepared FUEL FEEDLINE CONFIGURATION Checked Approved INPUT GROUP 4 MIDMLH - TOTAL NUMBER OF COMPONENTS IN MAIN HYDROGEN FEEDLINE (UP TO 100) MIDELH(NL) - TOTAL NUMBER OF COMPONENTS IN ENGINE HYDROGEN FEEDLINE NUMBER NL (UP TO 100) IDMLH - COMPONENT TYPE FLAG FOR MAIN HYDROGEN LINE IMMLH - COMPONENT MATERIAL FLAG FOR MAIN HYDROGEN LINE IIMLH - COMPONENT INSULATION FLAG FOR MAIN HYDROGEN LINE IMLH - SUBSCRIPT DENOTING COMPONENT POSITION IN MAIN HYDROGEN FEEDLINE (IMLH = 1 AT TANK BOTTOM) IBLH(NL)-SUBSCRIPT DENOTING COMPONENT POSITION IN ENGINE HYDROGEN FEEDLINE (IEIH(NL) = MIDELH(NL) AT INLET TO ENGINE NO, NL SP1MLH(I), SP2MLH(I), SP3MLH(1) - COMPONENT SPECIFICATIONS (SEE MANUAL) HPD(K), K=1, NEL- DIAMETERS OF HYDROGEN ENGINE FEEDLINES (INCHES) HPD(K), K=NEI+1, NSIZE - CANDIDATE DIAMETERS OF MAIN HYDROGEN FEEDLINE (INCHES) FORMAT ((1216)) COMPONENT COUNT CARD (FIRST CARD) MIDELH (NEL MIDELH(1) COMPONENT DESCRIPTOR CARDS FOR MAIN FEEDLINE FORMAT (316,E12.8) (THERE MUST BE MIDMLH OF THESE CARDS) IIMIH COMPONENT DESCRIPTOR CARDS FOR EACH ENGINE. FEEDLINE (THERE MUST BE MIDELH(NL) OF THESE CARDS FOR EACH ENGINE FEEDLINE NO'S 1 THROUGH NEL) FORMAT (316,E12.8) DELH IMELH ITELH

LMSC-A991396 LOCKHEED AIRCRAFT CORPORATION Propered FUEL FEEDLINE CONFIGURATION Cheched INPUT GROUP 4 (CONTINUED) Approved Fuel Feedline Diameter Cards FORMAT ((6E12.8)) NSIZE = NEL + NML HPD(1) HPD(NEL) HPD(NEL+1) HPD(NSIZE) - ENGINE FEEDLINE DIAMETERS ----MAIN FEEDLINE DIAMETERS TIMO OMIT TIMO

A-9

Prepared	HAME	DATE	LOCKHEED AIRCRAFT CORPORATION	Pa 70	TEMP.	PERM.
Checked	,		FEEDLINE HEIGHTS AND DESIGN	Made1		
Approved			PRESSURES - INPUT GROUP 5	Report	No.	

OXHTIN - FEEDLINE HEAD HEIGHT ABOVE ENGINE INIET,OXID, (FT)
HYHTIN - FEEDLINE HEAD HEIGHT ABOVE ENGINE INIET,FUEL, (FT)
PDLO - OXYGEN FEEDLINE DESIGN PRESSURE (OPTIONAL) (PSI)
PDLH - HYDROGEN FEEDLINE DESIGN PRESSURE (OPTIONAL) (PSI)

NOTE: A FACTOR OF SAFETY OF 2.5 IS APPLIED BY THE PROGRAM TO THE ABOVE PRESSURES IN THE COMPUTATION OF LINE WALL THICKNESSES, IF (PDLO, PDLH), LE, O, PROGRAM USES MAXIMUM TANK BOTTOM PRESSURE OR ENGINE INLET PRESSURE.

FORMAT ((6E12.8))

ØXHTLN	НХНДГИ	PDLØ	PDLH	
1 2 3 4 5 8 7 8 8 16 11 12	12 14 19 16 17 18 18 38 21 22 23 34	ванивинии и и и в	ग्रम के ब्रा द द व द द र व	48 80 51 52 53 54 56 56 58 57 56 50 60 61 62 63 64 55 56 67 68 69 70 71 72 73 74 75 76 77 78 70 80

CMIT

OMIT

Chocked INTITIAL WEIGHTS LOADO1 - LOADED WEIGHT OF OXIDIZER, LB. LOADH1 - LOADED WEIGHT OF FUEL, LB. LOADH1 - TOTAL VEHICLE WEIGHT AT IGNITION, LB. FORMAT ((6E12.8)) LOADO1 LAADED WEIGHT OF FUEL, LB. VNOTN - TOTAL VEHICLE WEIGHT AT IGNITION, LB. FORMAT ((6E12.8)) CHIT	·				 			LMSC-A9	<u>91396</u>		
INTUL WEIGHTS Appared INFUT GROUP 6 Report No. LOADO1 - LOADED WEIGHT OF CXIDIZER, LB. LOADN1 - LOADED WEIGHT OF FUEL, LB. VWGTN - TOTAL VEHICLE WEIGHT AT IGNITION, LB. FORMAT ((6E12.8)) LOAD91 LOADH1 VWGTN CMIT	Prepared	· M	AME	DATE	<u> </u>	CKHEED AIRCR	AFT CORPOR	ATION			PERM,
LOADO1 - LOADED WEIGHT OF CXIDIZER, LB. LOADH1 - LOADED WEIGHT OF FUEL, LB. VWGIN - TOTAL VEHICLE WEIGHT AT IGNITION, LB. FORMAT ((6e12.8)) LOADØ1 LOADED WEIGHT OF KUEL, LB. FORMAT ((6e12.8)) CMIT	Checked				TITLE	INITIAL W	EIGHTS		Model		
IOADH1 - IOADL VEHICLE WEIGHT AT IGNITION, LB. FORMAT ((6E12.8)) LØADØ1 LØADH1 VWGTN	Approved					INPUT GRO	UP 6		Report	No.	
LAADA LAADH VWGTN CMIT		OADO1 - OADH1 - WGTN -	LOADED VIOLATION LOADED VIOTAL VI	VEIGHT OF WEIGHT OF SHICLE WE	OXIDIZE F FUEL, I	R, LB. B. IGNITION, LB	•				-
LAADAT LAADHI VWGTN CMIT											
	FC	RMAT ((6 E 12.8))			-	· · · · · · · · · · · · · · · · · · ·				
	LØADØ	1	LØADH1	VWGI	'N		•				
ា 2 3 4 9 0 7 0 0 (i) បោះ អេកការ (i) (i) អាការ អាការ អាការ អាការ អាការ អាការ (i) (ii) (ii) (ii) (ii) (ii) (ii) (ii)	123456	7 0 0 16 11 12	12 14 19 16 17 18 19 20 ₁ 2	12235272	28 28 28 28 28 28 28 28 28 28 28 28 28 2	2 2 2 d 11 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	e e m'ii m n n n n n n	30 m/s1 12 13 64 13 68 67	GL 69 70 71 77		מנות מו זו
ា 2 3 4 9 0 7 0 0 (i) បោះ អេកការ (i) (i) អាការ អាការ អាការ អាការ អាការ អាការ (i) (ii) (ii) (ii) (ii) (ii) (ii) (ii)											
OMIT		7 8 8 10 N1 12 I	3 14 15 16 17 18 18 28 71	מת א מ א מ ע	•:		u 4 m(s) 12 12 34 35 35 35 35	30 (a) 51 (51 (51 (51 (51 (51 (51 (51 (51 (51	sa es 10[71 7:	72 14 73 75	77 78 78 80
OMIT								,		•	
an K il K K K K K il il k k k k k k k k k k k k k k k k k		, , , , , , , , , , , , , , , , , , ,	Na 15 Na di Ma man	y na sh s	OMIT			n eli commun		nann	77 79 79 80

A-11

HAME LOCKHEED AIRCRAFT CORPORATION Prepared TITLE STEADY-STATE Checked ENGINE CONDITIONS INPUT GROUP 7 Approved Report Ho. WDOTNO - OXIDIZER NOMINAL FLOW RATE FOR SINGLE ENGINE (LBS/SEC) WDOTNH - FUEL NOMINAL FLOW RATE FOR SINGLE ENGINE . (LBS/SEC) FNOM. - NOMINAL THRUST FOR SINGLE ENGINE (LBS) FORMAT ((6E12.8)) WDØTNØ WDØTNH FNM CMIT TIMO

4-15

Proposed Pare LOCKHEED AIRCRAFT CORPORATION Proposed Checked INPUT GROUP 8 Permit Parks.

LMSC-A991396

TEMP. Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18 Parks.

Page 18

TENINO - TEMP. OF OXID. FLUID AT ENGINE INLET

TENINH - TEMP. OF FUEL FLUID AT ENGINE INLET

TLIQSO - TEMP. OF OXID. FLUID SURFACE IN TANK

TLIQSH - TEMP. OF FUEL FLUID SURFACE IN TANK

PENTOL - ENGINE INLET FLUID PRESSURE TOLERANCE

(PSI)

FORMAT ((6E12.8))

TENINØ TENINH TLIQSØ TLIQSH PENTØL

OMIT

OMIT

LMSC-A991396 TIME VALUES FOR TRANSIENT DATA Report No.

TIMEA - TIME VALUES OF EVENTS IN TRANSIENT (UP TO 21)

TITLE

DATE

FORMAT ((6E12.8))

Propered

Checked

Approved

TIMEA(1) TIMEA (2) TIMEA (NPTS)

LOCKHEED AIRCRAFT CORPORATION

INPUT GROUP 9

TIMO

TIMO

TIMO

LMSC-A991396 LOCKHEED AIRCRAFT CORPORATION HAME Propered PROPELLANT FLOWRATE HISTORY Checked INPUT GROUP 10 Approved MOTTRO - FRACTION OF OXIDIZER FLOW RATE AT TIMEA(I) WDTFRH - FRACTION OF FUEL FLOW RATE AT TIMEA(I) FORMAT ((6E12.8) WDTFRØ(1) WDTFRØ(2) WDTFRØ(NPTS) NOTE: WDTFRH DATA START ON A NEW CARD WDTFRH(1) WDTFRH(2) WDTFRH(NPTS) TIMO OMIT

A-15

Propored	MAME	DATE	LO	CKHEED AIRCR	AFT CORPORATI	ON	Pego	TEMP.	-
Checked			TITLE	ENGINE START	THRUST HISTO	RY	Model	L	1
Approved				INPUT GROUP			Repor		
		· ·		· · · · · · · · · · · · · · · · · · ·	 		Trebes.		
FIFRAC(I) - FRACTION AT TIMEA	OF NOMI	NAL THRU	ST (FOR A SIN	GLE ENGINE)				
FORMAT	((6E72.8))	•	-		· · · .				
	((3=13.37)		· ············						
FIFRAC(1) FIFRAC(2	2) .			FIFRAC(NPTS)				
								·	
			•						
1 2 3.4 8 6 7 8	1 11 11 12 13 14 13 16 17 16 18 26	1 22 23 24 25 26 27 28 2	9 30 JU 22 34 35 35	22 28 28 40 40 40 40 40 40 40 40 40 40 40 40 40	**************************************	2 5 K # # U	60 60 70 71 72	73 74 75 76	π
•			· · · · · · · · · · · · · · · · · · ·						
		. •		• .					
		·							_
		- 							
(•	•					
			OM]	· - ф				:	
								:	
1 2 3 4 5 6 7 8	10 11 12 13 14 15 16 17 16 16 20 3							11 11 15 16	
							· · · · · · · · · · · · · · · · · · ·		
					•				
			OMI	T.		•			
·									
		1 2 2 2 2 2 2 2 2 2		# # # #		2 D M U M 67	as so 70 71 72	72 14 75 75 75 74 75 75	n:
 , , , , , , , , , , , , , , , , , ,	10 11 12 13 14 16 16 17 18 18 2			Y 2 2 44 1 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	4 8 11 8 21 4 31 31 51 51 51				
123486761	10/11 12 13 14 10 10 17 10 16 20/2								
	1 10 11 12 13 14 10 10 17 11 19 20 2						·		
123459781	MI 11 12 13 14 80 10 17 13 16 20 2		·		48(1) 2 0 4 4 5 6 6 6		·		
123450761	MI 11 12 13 14 MI MI 17 18 18 20 2				48(11 2 11 11 11 11 11 11 11 11 11 11 11 11		·		
122459781	1 MI 11 12 13 14 MI NO 17 13 16 20 2				48(11 2 11 11 11 11 11 11 11 11 11 11 11 11				
	1 MI 1				48(11 2 11 11 11 11 11 11 11 11 11 11 11 11			-	_
	1 MI 1				48(1) 2 D V V B B B B				
	1 MI 1		OMI						

A-16

Propered	•	AME	DA	TE	LO	CKHEED A	RCR/	AFT CORPORAT	ION	Pa pro	TEMP.	PERM.
Checked					TITLE	UCTION PR	ŒSSU	URE REQUIREMEN	NTS	Model		
Approved						INPUT				Ropert	N.	
	PSPO -	NET POSI	יידעדי	SUCTI	ON PRES	SURE FOR	OYTE)TZER		PSI	Ma.	
		NET POSI	TIVE	SUCTI	ON PRES	SURE FOR	FUEI	1	•	PSI		
· F	ORMAT((6E12.8))		•	•	•		•	• .•			
	·			•					·			
NPSPØ(1)	NPSPØ(2)			•			npspø(npts)	·			
								·				
	7 e e 12/11 12	244997992		5 3 7 3 3 1			444			a nin n	D 14 75 76	пппи
L								<u></u>	<u> </u>		<u> </u>	
	N	OTE: NPSP	H DA!	TA STA	RT ON A	NEW CARI)	•				
		• .	. •					·				
		,					_					
NPSPH((1)	NPSPH(2)			•			NPSPH(NPTS)				
] .			
		,							ļ			
,,,,,,	, , , m 11 13	2 4 15 19 19 19 20	וכממ			7 x 200 c 4 4	5 6 0 6	- miss 22 22 24 26 26 27 28 28 18	n er er 14 85 96 67 8	n n n n	nnan	пъпю
L		<u> </u>	1			<u> </u>		<u> </u>	<u> </u>	<u></u>	<u> </u>	
	,								_			
		•			OVT.							
, [OMI			•	•			
		٠.				• • •		į				
12244	ւ օ տիոս	13 14 15 16 17 18 18 28 2	2222		пинка	2 2 2 4 11 4 4 4 H			(현 및 및 M ES NE 67 E	99 70 71 72	пивв	"""
	·			·		•		•	e e de la composition della co			
	•					٠					•	
								· · · · ·				
<u>;</u>												
/						•						- [[
					·-	_						
		•		•	OMI	Ψ'					٠	
			,									- }}
			2 D > 2	#####					11 W W M M M 17 M	מולת מ	73 74 78 78 T	7779
									<u> </u>			

Prepared		HAME	DATE	LO	CKHEED AIRCR	AFT CORPORAT	ION	Peno	TEMP.	PERI
Chacked					NGINE INLET RESSURE REQUI	REMENTS		Madel	,	
Approved	,				NPUT GROUP 13			Ropert	No.	
]	PENMNH -	MINIMUM MINIMUM (6E12.8))	ENGINE II	NLET OXID NLET FUEL	. PRESSURE VAI	ALUE AT TIMEA LUE AT TIMEA		PSI PSI		
PENMI	nø(1)	PENMNØ(2) .		· · ·	PENMNØ(NPTS)				
1 2 3 4 5	6 7 6 8 15 11 12	13 14 13 10 17 10 18 30 J	12345578	***************************************	7334 00000000	0 m/H 02 23 43 8 7 8 8 8	51 12 45 14 16 6 6 67 2	s as 78[71 72	2 74 75 74 1	17 75 79 I
	NOTE:	START A	NEW CARD	FOR PENM	NH DATA					
PENMI	NH(1)	PENMNH(2)	· • .		PENMNH(NPTS)		:		
12345	6 7 8 9 10 11 12	13 14 15 16 17 18 18 28 J	12235378	ампиимия	ग्रम क्यांत द्वास्त्र स्टब्स्ट स्टब्स	5 M(II IZ 55 M 58 58 57 58 58 58	R & 12 M 65 66 67 6	a n n n	13 74 75 76 7	n 76 79
				TIMO						
12245	6 7 6 9 10 11 12	13 14 15 16 17 16 19 25 2		пянкки	ए हे इन्द्री। स्टब्स द व ग ब	a min z n u u u n n n n	b) 12 43 04 83 RE 67 업	เดลไกร	ו אל 15 אל מ <i>ד</i>	77 78 78 T
						· · · · · · · · · · · · · · · · · · ·				
	,			OMIT		;				

A-18

Propored	NAME	DATE	LO	CKHEED AIRCRA	AFT CORPORAT	ION	مناعر	TEMP.	PERM.
Checked			TITLE	N-CONDENSIBLE	PRESSURANT I	DATA	Medel		
Approved			·	INPUT GROU	JP 14		Rapert	No.	
PI	PDGOT - PART,PP PDGHT - PART,PP DRMAT ((6E12.8)	RESS. OF PF	ESSURANT ESSURANT	GAS IN OXID.	TANK TANK		PSI PSI		
PPDGØ		2)			PPDGØT(NPTS)	·		א ה זי נק	
	L						a w Ain a		
	NOTE: START	A NEW CARI	FOR PPI	OGHT	1		-		
PPDGH	I(1) PPGHT(2)		• •		PPDGHT(NPTS)				
121411	2 8 9 10 11 12 12 14 15 19 17 18 18	2 H I I Z 2 H Z I I I I I		एक के बीच द्वार व व द द व	00 TG(\$1 B2.35) 56 SB TG 57 SB TB GB	ត្រួយស្ន	מוו ת ביים	N 25 14 CC	77 74 20
	•		OMIT						
11141	7 8 5 He 11 12 14 16 16 17 18 18:	n n n n n n n n	n n n n n n n n	333 da 60 46 40 4	4 m li 2 5 M M M I 7 D M B	 	# 9 74 71 72 	7 14 K K	77 76 75 00
	•			•					·
			OMIT						
1114141			инияная :	A 10		n er er er er er er	n n n n	n 14 m m 1	7778

Propored	. 1	MAME	DATE	LO	CKHEED AIRCRA	AFT CORPORAT	ION	Pege	TEMP.	PERM.
Checked				TITLE	ESSURANT GAS	TEMPERATURES		Madel		<u> </u>
Approved			· · · · · · · · · · · · · · · · · · ·		INPUT GROUP	15		Report	No.	
TDGOT TDGHT	- TEM	P. OF PRES P. OF PRES (6E12.8))	SSURANT G	AS, IF N	ONE-SET EQUAL ONE-SET EQUAL	TO TLIQSO +	5, DEG.R 5, DEG.R			
TDGØT(1)	TDGØT(2)	22 M 25 M 77 W 2	 	D 20 20 व्यं श व व व व व	TDGØT(NPTS)	31 位 拉 年 集 明 疗 相	10 70 71 72	72 74 72 76 7	מות מל לו
	NOTE:	START A	NEW CARD	FOR TDG	HT					
TDGHT(TDGHT(2)	ин ман паз		प्रक्रम्था द्य स्टब् ट व	TDGHT(NPTS)	ត្រ ប្រ ស ស ស រា ព	60 79 71 72	נאל או בל	77 79 80
L	•						<u> </u>		<u> </u>	
	7 8 9 Mh1 12	13 M 18 16 17 18 18 28 27		TIMO	•	6 10 11 21 21 14 28 27 28 28 28	ឯពលសសព ព	91 7a 21 72	23 14 25 26 7	775 M
-					• · ;				-	
			:	OMIT						

A-20

	MAME	DATE	LOCKHEED AIRCRAFT CORPORATION	TEMP. PENM.
Propored			End of Data for a Case	
Checked		·		Medel
Approved			INPUT GROUP 16	Report No.
			to be processed following this one.	•
IGØØN=	o, this is the return contr	last case ol to the	of the run. Terminate processing and computer operating system: FORMAT ((1216	5))
	,	·.		
ΙGØØΝ	į			
	·			•
		<i>:</i>		
1	7 6 8 10 ht 12 13 14 18 16 17 16 16 26		жи жи жи жи жи ми	1 10 70 71 72 72 74 75 76 77 78 28
<u></u>		·		
		NO FOLLOW	ING DATA CARDS ARE REQUIRED	·
	·			
	:			į
			OMTE	
	·		OMIT	
123411	7 8 9 10 111 12 13 14 15 16 17 18 18 20		対方 32 3. 32 32 32 34 44 44 44 44 44 44 44 44 44 44 44 44 	n (n) 70 77 77 78 78 78 78 77 77 78 80
٠,	•		·	·
	<u> </u>			
(
	•	٠	OMIT	·
			•	
1,,,,,	7			4 00 70 71 72 72 72 72 72 72 72 72 74 78 78 78 78 78 78 78 78 78 78 78 78 78
•		•		
	•			
		···		
(
			OMIT	
	•			
111444		,		1 40 70 11 72 72 74 75 75 77 75 96